



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

NYPL RESEARCH LIBRARIES

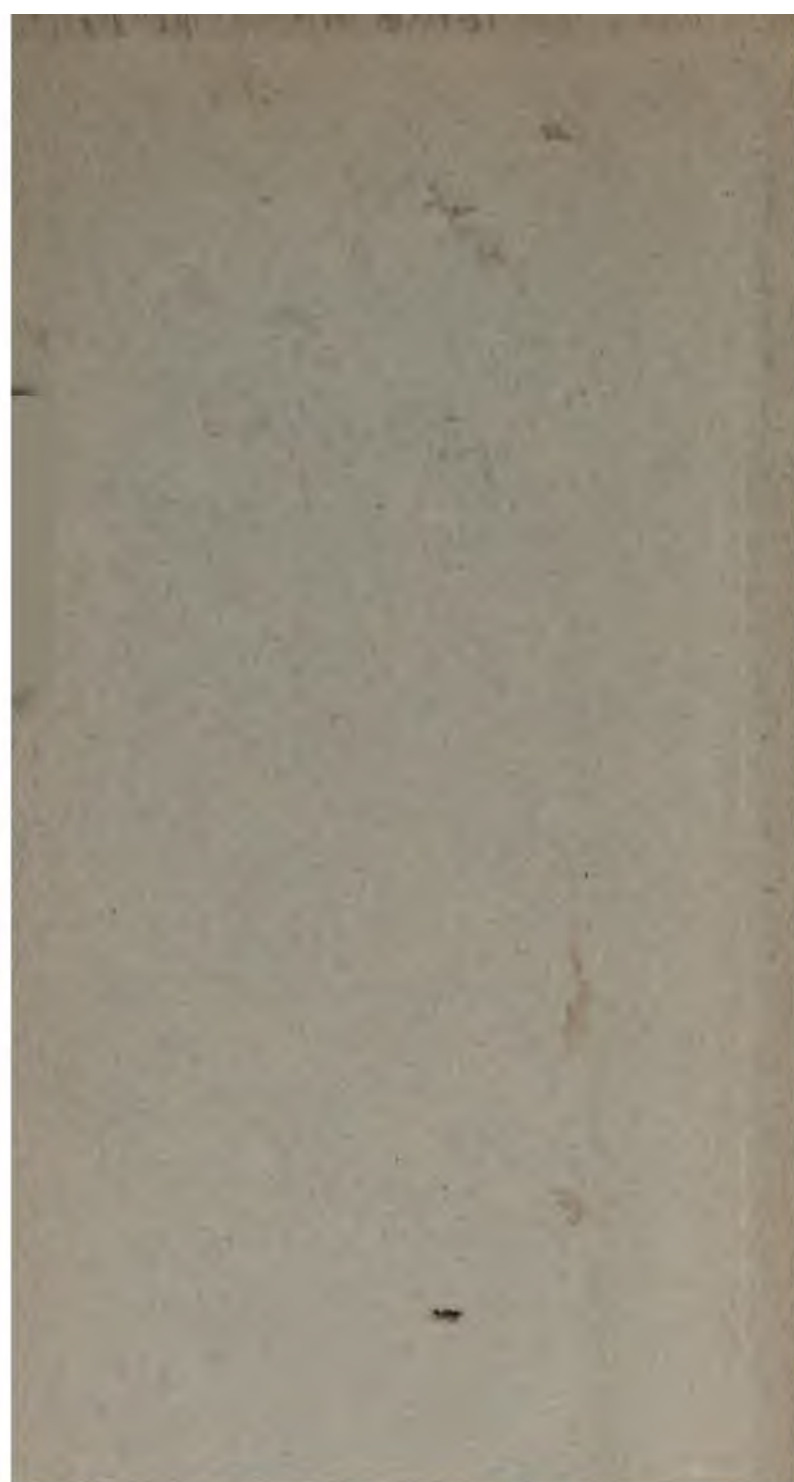


3433 06274059 6



Henison

OA



(Hewison)
CA

1

2

3

4

5

6

7

VOL. IV.

PARTS I AND II.

THE BULLETIN OF DENISON UNIVERSITY.

Edited by C. L. HERRICK.

TABLE OF CONTENTS.

PART I.—LABORATORY RESULTS.

1. Editor's Table. Scientific Buildings. Plate XV. p. 2-4
2. Lithological Notes on Contact Phenomena in South Carolina.
Plate XII. G. F. RICHARDS p. 5-10
3. Geology of Licking County, Ohio. Part IV. List of Waverly
Fossils, continued. Plates I-XI. C. L. HERRICK. p. 11-60
4. List of the Bryozoa of the Waverly Group in Ohio. Plates
XIII-XIV. E. O. ULICH. p. 61-96
5. Geology of Licking County, Ohio. Part II, continued. C. L.
HERRICK. p. 97-123
6. Tabulated List of Fossils known to occur in the Waverly of Ohio.
W. F. COOPER. p. 123-129
7. Miscellaneous Notes. (a) Peculiar Habit of the Fresh-water Hy-
dra. W. G. THOM. p. 129
(b) List of Algae collected at Granville. C. L. PAYNE. p. 130

PART II.—EDUCATIONAL AND LITERARY.

1. Educational Briefs.
2. Books and Authors. Latze's Ontology.
3. The Personal Element in Instruction. C. J. BALDWIN, D. D.
4. Pronunciation of Latin and Quasi-Latin Scientific Terms. PROF. CHAS.
CHANDLER.
5. Chamisso, the Naturalist and Philologist. PROF. GEO. F. MCKIBBEN.

GRANVILLE, OHIO, DECEMBER, 1888.

1327

Denison University, Granville, Ohio.

GRANVILLE COLLEGE—FACULTY AND OFFICERS.

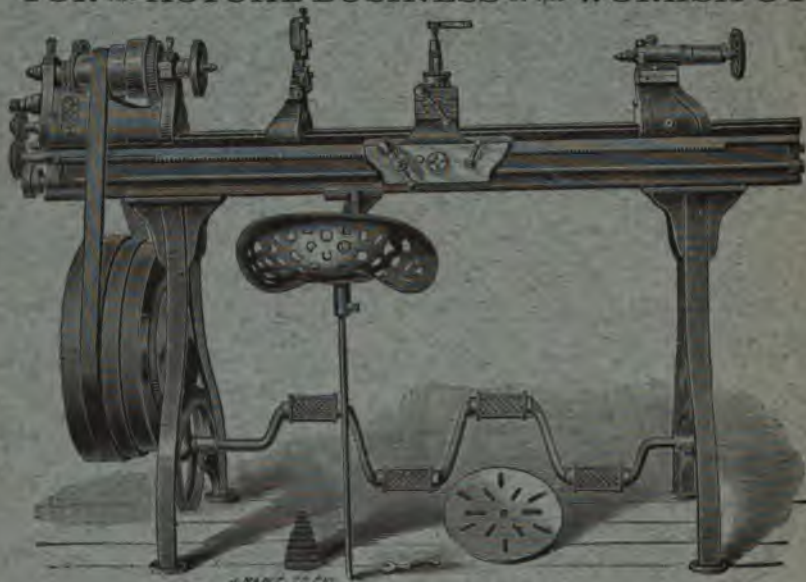
Rev. Galusha Anderson, D. D., I. J. D., *President.*
Almon U. Thresher, A. M., *Prof. of Rhetoric and English Literature.*
John L. Gilpatrick, A. M., *Prof. of Mathematics.*
Charles Chandler, A. M., *Prof. of Latin.*
Rev. Richard S. Colwell, B. D., *Prof. of Greek.*
George F. McKibben, A. M., *Prof. of French and German.*
Clarence L. Herrick, M. S., *Prof. of Geology and Biology.*
Alfred D. Cole, A. B., *Prof. of Chemistry and Physics.*
William G. Ticht, M. S., *Instructor in Natural Science.*

GRANVILLE ACADEMY—FACULTY AND OFFICERS.

J. D. S. Riggs, A. M., *Principal.*
Leverett E. Akins, A. M., *Instructor in Mathematics and Physics.*
William H. Johnson, A. B., *Instructor in Greek and Latin.*
Herbert L. Jones, A. B., M. S., *Instructor in Natural Science.*
William S. Burns, *Instructor in History.*

BARNES' PATENT FOOT POWER MACHINERY

FOR the ACTUAL BUSINESS of the WORKSHOPS



Outfits complete for Schools of Industrial Training—with them a Practical Journeyman's Trade, in wood or metal, can be acquired. Illustrated catalogue free. Address

W. F. & JOHN BARNES CO.,
479 RUBY STREET, ROCKFORD, ILL.

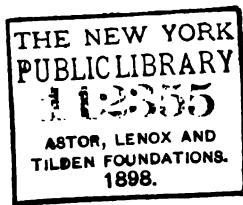
BULLETIN
OF
DENISON UNIVERSITY

C. L. HERRICK, EDITOR.

VOL. IV., PART I.

[Material from the Scientific Laboratories.]

GRANVILLE, OHIO, DECEMBER, 1888.



ERRATA.

- Page 12. For LINGULA WAERLYENSIS, read L. WAVERLIENSIS.
Page 14. For CHONETES TUMIDUS, read C. TUMIDA.
Page 18. For L. WAVELYENSIS, read L. WAVERLIENSIS.
Page 24. The figure referred to as Fig. 12, of Plate III, has been omitted from the plates.
Page 29. For ALLORISMA CONSAGUINATUS, read A. CONSANGUINATA.
Page 37. Under bibliography, for MACORDON, read MACRODON.
Page 38. Under C. ovata, for PLATE IV, FIG. 6, read FIG. 5.
Page 43. et seq. The proper orthography is probably PALEANEILO.
Page 44. For NUCULA HOUGHTONI, STEV., read N. HOUGHTONI, WIN.
Page 45. For FLEMINGIA STULTUS, read F. STULTA.
Page 54. For PHILLIPSIA (PROETUS) AURICULATUS, read PROETUS (PHILLIPSIA?) AURICULATUS, and make the same change in case of P. praecursor.
Page 54. For PHILLIPSIA MERAMACENSIS, read P. MERAMECENSIS.
Page 78. For PLATE IV, read PLATE XIV.
Page 99. Correct the numbering of the paragraphs.
Page 100. For SHUZODUS, read SCHIZODUS.
Page 101, (16). Add, at end, 100 FEET.
Page 107. Six lines from bottom, for ELIKE, read LIKE.
Page 118. Under Plate III. instead of LEIORHYNCHUS, read LEIORHYNCHUS.

WE embrace this opportunity to extend public thanks to those who have aided in the work here represented. To Prof. L. E. Hicks for a valuable collection of New England plants collected by A. R. Crandall. To Prof. W. H. Johnson for a fine suite of fresh-water vertebrates, mostly fishes, from the Ohio river. To Mr. Geo. W. Spellman for a collection of Trenton fossils from Southern Wisconsin. To Mr. J. A. Smith for a collection of about fifty plants from Mercer's Bottom, West Virginia. To numerous scientific societies and individuals who have added to our library. To all who, by word of cheer or pecuniary aid, have encouraged the project of enlarging the scope and increasing the efficiency of the scientific departments.

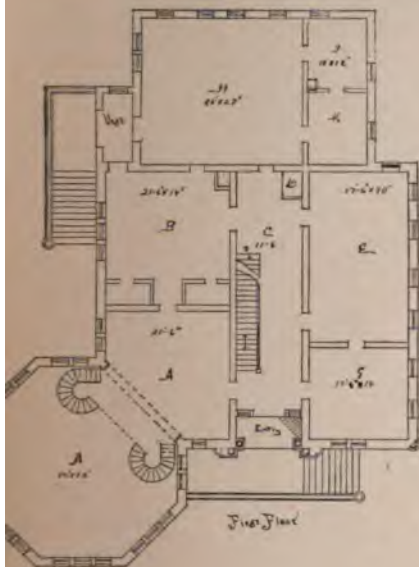
We present herewith an elevation and diagrams of a building intended to accommodate the scientific departments of one of the smaller colleges. The plan was suggested by the departments and has been elaborated by the Messrs. Richards, architects, of Newark, O. The design was to comfortably house and provide for such an outfit as would best subserve the requirements of a modern college with less than five hundred students. At the same time, the building is so arranged that, by the removal of a few slight partitions, it is easily adapted to the sole use of the departments of Geology and Biology, and the necessary museums and laboratories. The following advantages incident to this plan should be noted. The space is rigorously economized. The museum is essentially distinct from the laboratories and class-rooms, yet is closely united to both, as well as convenient to the entrance. In this way the museum may be rendered fireproof without fire-proofing the entire building. The class-room of geology is so arranged that, by removing iron shutters which move on weights the gallery of the museum is instantly brought within the view of the entire room, thus enabling the instructor to point out the various geological periods as illustrated by the charts and cabinets without disturbing the recitation. A door leads from the geological class-room to the gallery and from the preparator's room to the first floor of the museum. The single large lecture room is equally eligible to both departments and is of the amphitheater style so much in vogue abroad. There are approaches from without, as well as from the hall, so that

classes may leave the building without disturbing others engaged in laboratory practice. The first, or basement floor, is devoted to a light and convenient work-shop. The shaft running the iron and wood-working machinery is continued into the lathe room of the lithological laboratory. The laboratories for physics are supplied with firm piers for delicate instruments, while microscope tables in the biological rooms may be so bracketed to the walls as to be quite independent of possible floor vibrations. A large and well-lighted room in the attic may be used in any way desired. The following added particulars are furnished by the architects:

The building will cover a space 56 ft. 8 in., by 79 ft., exclusive of entrance porches or tower projections. The octagonal museum room has a projection of 22 ft. 6 in. The materials used in construction will be native freestone and pressed brick, trimmed with Kilbuck brown sandstone, and, for the roof, slate and iron. The interior should be furnished in cherry, oak and ash. The building will be heated by steam, lighted by electricity from dynamos in the basement, and ventilated by the latest improved methods. Water plumbing throughout, with toilet rooms and the L. B. Robb patent crematory closet system complete the appointments of the building proper. The estimated cost falls between \$25,000 and \$35,000, depending upon the details of construction.

EXPLANATION OF DIAGRAMS.

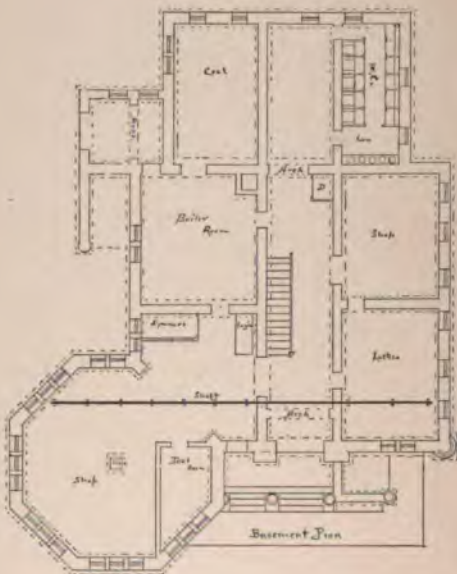
- A. Museum.
- B. Biological preparation room with dark-room and closet.
- C. Halls.
- D. Elevator shaft.
- E. General physical laboratory.
- G. Delicate instruments.
- H. Lecture room, with raised amphitheater seating.
- I. Chemical preparation room.
- K. Physical preparation room.
- L. Chemical laboratory.
- M. Lift.
- N. Stock room and dark room.
- O. Balance room. Spectroscope room adjoining dark room.
- P. Mineralogical laboratory.
- Q. Class-room of mineralogy and geology, separated from gallery of museum by glass sash and a steel shutters.
- R. Chemical laboratory study. Organic and gas analysis.
- S. Biological laboratory.



Richards Brothers, Architects
Newark, Ohio.
First Elevation
Front of



Richards Brothers, Architects
Newark, Ohio.
Second Floor



Basement Floor





A.



B.

LITHOLOGICAL NOTES ON CONTACT PHENOMENA IN SOUTH CAROLINA.

By GARY F. RICHARDS.

[Read Before Denison Scientific Association, May, 1888,]

The rocks treated in this article are from Spartanburg Co., South Carolina. They were obtained by Prof. Herrick, while on a geological trip through those states last summer vacation, and kindly given to me for study. Part of the slides were made by the Professor, the rest by the writer.

The first sample is from a dyke lying near Pacolet Mills, S. C., which stretches from north-east to south-west for about five miles in an irregular boss, forty feet wide at the point viewed. Two miles to the east of the dyke is a large granite area which disappears beneath gneiss as we approach the dyke. This is lost just west of the dyke and schist takes its place, which is traced through its different varieties for two miles, when we arrive at a pure steatite rock. The section of that district would be as follows: First the granite underlying the whole, on this would be found the gneiss, and lying on that the schist; the dyke perforating the granite and gneiss; the whole unconfortable.

The hand sample, taken from within the dyke towards the centre, is dark gray, almost black, and presents a fine crystalline structure; the lath-shaped crystals stand out quite distinctly. Studied microscopically, the section presents a field of which nearly one-half is plagioclase, in long lath-shaped crystals. The plagioclase is labradorite, and the twinning is mostly after the albite law, but there are some beautiful examples of perikline twins. Interpenetration of the plagioclase is quite common in this section, and several of the crystals show indications of having been formed under pressure. The plagioclase was the first formed mineral, as indicated by the regularity of its outline. Aug-

ite is also present in abundance in short, irregular crystals, some of which is uraltic, showing alteration to hornblende, and contains inclusions of magnetite grains. Some of the augite grains are polysomatic. Olivine is also scattered through the section showing brownish alteration along margin and cleavage lines. Magnetite and apatite are also present together with a few grains or scales of hematite. No garnets were found in this section. Dialage is doubtfully determined. The rock is a typical Olivine Diabase.

The next sample studied was obtained near this trap and is of a coarser granular structure and lighter colored. Large crystals of quartz and plagioclase are scattered through it. In section the same displays a field, the greater portion of which is hornblende in short irregular crystals, forming the main mass of the rock. Through this are scattered crystals of orthorhombic augite, enstatite, apparently an alteration product of the hornblende. The plagioclase is in small lath-shaped crystals of labradorite and together with quartz, forms a small portion of base. A few crystals of magnetite and apatite are present with a few scales of hematite as an alteration product of magnetite. Another rock sample taken from near the contact line, is of a finer crystalline structure having cooled more rapidly from a state of fluidity. It is dark gray in color with reddish brown spots containing garnets scattered throughout; one exposed edge giving indications of weathering. In section we find hornblende in short irregular crystals forming nearly one-half the mass with labradorite feldspar in abundance, and interpenetration quite noticable as indicating secondary origin. They also contain cavities of air or glass. Garnets in some cases occupy a great part of the field; they are of a salmon red color and contain inclusions of magnetite dust and fluidal cavities. Near these is found quartz and feldspar and a little magnetite in regular sections. These two last rocks mentioned are Diorites and are thought from the position and structure to be products of the action of the diabases upon the metamorphic rock through which the diabase has forced its way to the surface. The gneisses and schists, according to the geological map of that state, lie unconformably upon the underlying rock and have probably a sedimentary origin. The diorites seem not to be simply diabase altered to diorite, as maintained by Mr. Wadsworth, but are perfectly fresh and it rather seems that these rocks are paragenetic and the formation of diorite is accounted for by contact with the diabase, which by means of its heat fused the surrounding

local rock to a plastic mass, which upon recrystallization assumed the distinctive characteristics noted above.

The next rock studied from this neighborhood is a piece of fine-grained gneiss, of dark greenish gray color almost schistose structure and is from the rock surrounding the trap. When studied microscopically, we find the greater part of it to be hornblende in short, irregular crystals, with a few large crystals of the same containing inclusions of apatite, with magnetite and calcite as product of alteration. Quartz is present with a few scales of biotite and many crystals of apatite. One thing noticeable in the rock, is the peculiarity of the form and occurrences of the calcite. In almost every case observed, it was formed either lying within or adjacent to a crystal of hornblende and always enclosing grains or skeletons of magnetite, except in two or three cases and in those cases the enclosed particles are hematite, which are undoubtedly alteration products of magnetite. The calcite has apparently assumed the form of the original magnetite crystal or the space occupied by it and the adjacent hornblende alteration product.

Fig. 1. Sec. A., is a crystal of hornblende containing calcite (c) undoubtedly an alteration product, and enclosing a crystal of magnetite; (a) is a cross section of apatite. Fig. 2, is a crystal of calcite with slightly greenish tinge, as indicating its probable origin, showing the cleavage of calcite and surrounding a grain or skeleton of magnetite. Fig. 3, is a crystal of calcite with an enclosed scale of hematite altered from magnetite. It will be noticed that the calcite grains are nearly regular in shape and apparently assume the form originally held by the magnetite. Such is the case in almost every instance. There are however, a few crystals, as in Fig. 4, where the hornblende has altered along the edges with the magnetite skeleton within, and the whole forming an irregular crystal.

Two theories are proposed in regard to this change; one is that it was brought about by the presence of carbonic acid in the interstitial water of the rock, by means of which interaction was set up between the magnetite and hornblende, substituting iron for calcium in the latter, depositing some of its calcium as calcite about the remnant of the magnetite; or it may be a pseudomorphic product of the hornblende leaving the magnetite as a residue.

Our two next studies are different phases of granite from the quarry about two miles east of the dyke. The rock is a true granite and is extensively quarried. Macroscopically they differ in general only in color. One a dark and the other a light gray, with, perhaps, slight indications of weathering on the surface of the darker rock. It

also contains small brownish crystals, that might be taken for garnets, but are simply colored augite. There also passes across this specimen a small greenish segregation vein. Microscopically, the specimen presents a field in which quartz and orthoclase are abundant, considerable biotite, epidote, some calcite, augite, hornblende, a little muscovite, oligoclase, magnetite, and a few scales of hematite. The biotite is in both long and short crystals. The epidote is in slender irregular crystals of a greenish yellow color, in some instances showing paramorphic alteration from hornblende. One peculiarity of this granite is the presence and abundance of augite in association with orthoclase, which is a rare thing; but here the numbers of augite crystals are surprising. It varies from brown to pale brown in color. The other phase of this rock, as has been said, is of a lighter shade, somewhat speckled and of coarser crystalline structure, with some of the constituents distinguishable by the unaided eye. Microscopically, the section shows quartz and orthoclase in considerable quantity. Biotite is present, and in some cases shows pseudomorphic alteration from hornblende. Muscovite is more abundant than in the former, in irregular grains, with hornblende, calcite, and a little magnetite.

The three following rocks studied, are different phases of the schist of this region and present a very interesting problem on account of the topographical and lithological evidence they furnish of the gradual alteration from actinolite schist through the various other varieties of schist to the pure steatite or soapstone. There is a quarry of this soapstone, about two miles from the dyke, and its merchantile value gives it at once a leading place in interest.

The first rock studied is a schist taken at some distance from the soapstone. To the unaided eye it is dark green in color with fine felting of crystalline rods, and harsh gritty touch. Under the microscope it presents a field of actinolite-hornblende, very beautiful either with or without the polarizer, on account of the distinct outline of the crystals, many of which have a beautiful yellowish green border. Some of the crystals of hornblende are partly altered to tremolite as in Fig. 5, Sec. B, showing the green of the hornblende (h) and white of the tremolite (t) in different parts of the same crystal; the alteration is incomplete. All stages of transition from actinolite to tremolite are observable. Others have made a further change and are taking on the fibrous structure of talc. The rock is an actinolite-schist with tremolite, a little magnetite

and yellowish isometric crystals of alteration product not yet further determined.

The second sample taken nearer to the soapstone quarries, is a fine grained crystalline rock, brownish gray color with here and there groups of garnets of a rusty appearance. Talc is perceptible to the unaided eye. Under the microscope we find the field mainly hornblende of a brownish color, all more or less altered. An unresolvable mass of "opacite" is scattered through it. Also numerous large scales of talc more abundant in this than in the former sample. Some scales of biotite, quartz, magnetite crystals, a little muscovite and a few small garnets.

The next rock is the steatite rock itself. In hand sample it presents a felting of stellate or rosette masses of crystals, of light greenish gray with brownish or ochre colored aggregates at centre of rosettes. The whole has an unctuous touch. Microscopically, it is seen to be almost wholly talc with here and there large crystals showing traces of the form of original hornblende.

Comparing our studies of these three rocks, we find the first an Actinolite schist with the hornblende almost pure and containing tremolite and a few talc crystals; and as we draw nearer to the soapstone, we find the rock to contain hornblende all more or less altered with more talc present, making it a talc schist, until we reach the pure talc rock containing but few traces of the original hornblende structure. Followed consecutively, the change would probably not be so apparent, but from these samples taken at different distances from each other the change is quite marked, and we conclude that the soapstone was formerly a gneiss or schist and that its present condition is due to the alteration of the hornblende to talc brought about by atmospheric or hypogene forces. Whether the period occupied in bringing about the transformation was of long or short duration we cannot say.

In this series of rocks we find the points of interest to be the interpenetration and the periklinal twinning of the plagioclase crystals, some of which in the first diabase studied are evidently formed under pressure; the polysomatic structure of the augite in both diabases; the absence of garnets in the diabase and their presence in the adjacent gneisses, schists and diorites where ever studied, in which our experience differs from that of Mr. Lawson in his article in the April *Geologist*, where he says he finds garnets in the central portion of the dyke studied by him and none in contact rocks or schists, this leading

to the conclusion that garnets are of probable contact origin; then the peculiarity of the formation and occurrence of calcite in connection with magnetite which we have never noticed before in any rock we have studied;* the association of augite and orthoclase in granite—a very rare occurrence; and finally the gradual alteration of the schists to steatite or soapstone.

*See Rosenbusch, *Micro-Physiographie*. Vol. II, p. 247.

GEOLOGY OF LICKING COUNTY. PART IV.

By C. L. HERRICK.

LIST OF WAVERLY FOSSILS, Continued.

In this number a considerable number of additional species are described and additional information collected concerning many noticed in the last number. Especial pains has been taken to figure characteristic specimens of the new species and it is hoped that several deficiencies in the last paper are now met. The Bryozoa constitute the basis for a separate paper by Mr. Ulrich to whose generosity we are greatly indebted. It is frankly admitted that a great deal remains to be done, nevertheless this paper is based upon much larger collections of Ohio Waverly fossils than ever before accumulated and one derived from nearly all parts of the state,

If circumstances had permitted, it was intended to prepare an artificial key to genera and species of the Waverly group. This we can not at present do, for to make it of real value it should include the species of Michigan, Iowa, Tennessee and Pennsylvania. In a few cases a key has been prepared for brachiopods. The genera of Lamellibranchs can be collated by reference to Vol. V. of Palæontology of New York and the number of species here reviewed is too small to require special keys. In bringing this list to a close the leniency of students is relied upon in view of the extreme difficulty of the undertaking and the nature of the material. In the object set prominently before the mind, the reference of species to their exact horizon, we hope to have measurably succeeded.

KEY TO THE BRACHIOPODA OF THIS LIST.

A. BRACHIOPODA.

A'. LYOPOMATA.

Valves of the delicate shell not articulated by teeth, form sub-discoid or linguloid, texture more or less horny.

- I. FAM. DISCINIDÆ. Upper valve sub-conical or limpet-like, lower flat and perforated for the pedicel.
- II. FAM. LINGULIDÆ. Shell oblong or oval, valves nearly equal.

I. FAM. DISCINIDÆ.

Genus 1. DISCINA. Flat lower valve with a perforation on the posterior side, with an internal furrow.

Strangely enough no well-authenticated species of Discina is yet known in the Ohio Waverly. From other states the following are rather imperfectly known: *D. gallaheri*, Win. (Mich.) *D. patellaris*, Win. (Iowa), *D. saffordi*, Win. (Tenn). *D. capax* is thought a synonym of *O. newberryi*, and a specimen from Granville has been identified by Prof. Winchell with *D. gallaheri* perhaps on insufficient grounds.

Genus 2. ORBICULOIDEA. Furrow impressed from the outside instead of the inside the lower valve, opening at its posterior end.

Sp. 1. ORBICULOIDEA NEWBERRYI. H.

Nearly circular, apex of ventral valve one fourth diameter from the margin, indistinct radiating markings. Less than half an inch in diameter. Div. I, and especially just above Berea grit.

Sp. 2. ORBICULOIDEA PLEURITES. Meek.

Oblong elliptical, apex of ventral valve near border, depressed, ventral valve discoid with a deep depression posteriorly. Length nearly one inch. Shale over congl, I.

II. FAM. LINGULIDÆ.

Genus LINGULA. Characters of family.

Sp. 1. LINGULA WAVERLYENSIS. Herrick (L. scotia.)

Large species of sub-triangular form and distant raised concentric striæ.

Sp. 2. LINGULA MEMBRANACEA. Win.

Medium size, oblong, length to width as 12 to 6, beak rather acute. Above congl, II.

Sp. 3. LINGULA GANNENSIS. Her.

Medium size, oblong, length to width as 11 to 6, beak quite obtuse. Above congl. II.

Sp. 4. *LINGULA ATRA*. Herrick. (Described beyond)

Medium size, oblong, length to width as 9 to 5, beak larger than a right angle. Below 2d fall, Cuyahoga Valley.

Sp. 5. *LINGULA CUYAHOGA*. Hall.

Medium size, elongate oval, length and width as 11 to 6, beak nearly a right angle. Below 2d fall, Cuyahoga Valley.

Sp. 6. *LINGULA MEEKI*. Herrick. (Described beyond.)

Medium size, rather broadly oval or lepidiform, length to width as 12 to 8.5. Below 2d fall, Cuyahoga Valley.

Sp. 7. *LINGULA MELIE*. Hall.

Small acutely oval, length as 12 to 8, beak acute, with a depressed median line extending from the beak.

Shale above Berea grit.

We thus have an unusually large number of species, when it is remembered that the vastly thicker Chemung group in New York has not furnished a single species. (We have found a poorly preserved *Lingula* in Chautauqua Co., however.)

A". ARTHROPOMATA.

Valves thick, unlike, with hinge-teeth.

I. Fam. TEREBRATULIDÆ.

Shell punctate under a lense, more or less ovoid, smooth or striate, with a circular perforation of the the beak of ventral valve. Dorsal valve with an internal loop. Genera *Terebratula*, *Cryptonella*, *Centronella* only distinguishable by internal characters.

II. Fam. RHYNCHONELLIDÆ.

Shell not punctate, more or less triangular in outline and longitudinally plated, beak with a foramen.

Genus *Rhynchonella*, characters of the family.

III. Fam. ATRYPIDÆ.

Shell fibrous, beak with no area, not strongly plaited.

Genus *Atrypa* with radiating irregular striae.

IV. Fam. SPIRIFERIDÆ.

Form various, usually with strong radiating plicæ, and extended hinge line. Internally dorsal valve with calcareous coiled arm supports.

1. Genus *Spirifer*. Elongate transversely, hinge-line longest lateral dimension, radiatingly ribbed or plicate, somewhat tri-lobed.
2. Genus *Syringothyris*. Like *Spirifer*, with fold and sinus smooth, area of ventral valve high, area with a perforated deltidium leading into a funnel-like projection into the interior.
3. Genus *Spiriferina*. Small spirifers with few plicæ and a prominent partition in the ventral valve.
4. Genus *Martinia*. Hinge-line shorter than greatest width, surface spiny and concentrically grooved.
5. Genus *Cyrtina*. Like *Spiriferina* but with very high ventral valve, prominent deltidium closing foramen.
6. Genus *Athyris*. Transversely oval, concentrically striate, area obsolete, beak perforate, spires as in *Spirifer*.
7. Genus *Rhynchospira*. Surface striate or plicate.

V. Fam. STROPHOMENIDÆ.

Shell transversely oblong, with long hinge line and small areas, generally plano- or concavo-convex.

1. Genus *Orthis*. Hinge shorter than width, radiately striate, bi-convex.
2. Genus *Hemipronites*. Concavo-convex, hinge nearly as long as greatest width, area of ventral valve narrow, with deltidium, radiating striæ.
3. Genus *Strophomena*. Depressed, concavo-convex, area on both valves, radiating striæ.

V. Fam. PRODUCTIDÆ. Concavo-convex, with straight hinge, generally shorter than greatest width of shell, surface or hinge with long spines, surface porous.

1. Genus *Productus*. Whole surface with spines.
2. Genus *Chonetes*. Spines restricted to the hinge.

Genus CHONETES.

A. Of large or medium size, gently convex.

- a. Surface marked by over 100 ribs.

1. *C. MULTICOSTA*.
2. *C. ILLINOISENSIS*.

- b. Surface marked by 40-60 ribs.

3. *C. LOGANI*.

B. Very convex, of medium size.

4. *C. TUMIDUS*.

C. Of rather small size.

- a. Surface with over 50 rounded ribs, hinge with about six oblique spines.

5. *C. PULCHELLA*.

- b. Fewer striae, which are sharply raised, four oblique spines.

6. *C. SCITULA*.

The typical form of *C. illinoisensis* occurs at the very top of the series. A closely allied form, perhaps *C. multicosta* appears about seventy feet below conglomerate. *C. logani* is ubiquitous while *C. tumidus* and *C. scitula* belong upon the same horizon as *C. multicosta*. *C. mesoloba* must be excluded from the list.

Genus *PRODUCTUS*.

I. Species of large size (over $\frac{3}{4}$ inch.)

- A. Marked by fine, wavy, fasciculate radiating costæ.

1. *P. DUPLICOSTATUS*. Win.

- B. Marked by strong, radiating (and concentric) costæ.

- B1. Strongly pustulose.

(?) 2. *P. NEBRASCENSIS*.

- B2. Not strongly pustulose.

* Length over one inch.

† Costæ distant,

3. *P. BARICOSTATUS*. Her.
(— *P. dolorosa*. Win ?)

†† Costæ closely set.

- a. Ventral valve tumid, strongly arched over the hinge.

4. *P. SEMIRETICULATUS*.

- b. Ventral valve moderately tumid, less strongly arched over the hinge.

5. *P. NEWBERRYI*. Hall.

- ** Length less than one inch.

- a. With very coarse and irregular costæ, very strongly arched.

6. *P. ARCUATUS*. Hall.

- b. Striæ finer and more regular, less strongly arched.

7. *P. FLEMINGI*. Var.

II. Of small size, (mostly under $\frac{1}{2}$ inch.)

- A. Marked only by fine dichotomizing striæ.

8. *P. GRACILIS*. Win.

- B. Marked with fine concentric striæ and irregular coarse pustulose ribs.

- a. Very tumid with numerous spines on the ears, not strongly pustulose.

9. *P. RUSHVILLENSIS*. Her.
(= ? *P. morbillianus*. Win.)
- b. Surface pustulose, spines scattered.
- c. Beak truncated, much as above.
10. *P. SHUMARDIANUS*.
11. *P. CURTIROSTRIS*. Win.
- C. Surface slightly convex, with nearly equal radiating and concentric striae.
12. *P. NODOCOSTATUS*.

This list might be extended but some uncertainty would be introduced. The above species can be recognized with tolerable certainty. No. 1, occurs in division III, *P. nebrascensis* is perhaps not found in the the Waverly, the species so identified being possibly peculiar forms of *P. newberryi*. *P. semireticulatus* occurs in the upper part of division III, while its close ally, *P. newberryi* belongs in a lower zone in division I, but the two species seem to pass into each other in the northern part of the state. *P. flemingi*, var. *burlingtonensis* H, is from the uppermost horizon of division III. *P. rushvillensis* and *P. shumardiana* are very closely related, though the former is from the highest horizon of division III and the latter seventy feet below conglomerate II. *P. raricosta* is known only thus far from below the last mentioned horizon.

Genus RHYNCHONELLA

It is not at present possible to catalogue the Rhynchonellidae of the Waverly with any degree of success. Three types are easily separable.

- A. Large species with three to four plicae on the fold and sinus.
1. *R. SAPPHO*.
2. *R. SAGERIANA*.
- B. Rather large species with five to eight plicae on the fold and sinus.
- a. Abrutly deflexed around the front.
3. *R. MARSHALLENSIS*.
4. *R. COOPERI*.
- b.
- C. Smaller species with two to four sharp plicae on the deep fold.
5. *R. CONTRACTA*.
- D. Small species with slight or no fold.
6. ?

LINGULA ATRA, Sp. n.

(Plate X, Fig. 30.)

Ventral valve rectangularly sub-elliptical, length to width as 9 to 5, sides parallel, front margin truncate, cardinal slopes forming nearly a right angle, unbonal region rather distinctly convex, triangular area from front to beak flattened, lateral aspects gently sloping, dorsal valve

less convex and with a rounded inconspicuous beak ; surface marked by numerous rather distinct and unequal concentric lines. Length, 16 mm : width, 10.5 mm. The epidermis is of a deep black color in our specimens, but this may be due to the nature of the shale.

In form our species closely resemble *L. punctata* of the Hamilton but has very different surface characters. It needs no comparison with other Waverly species, being much shorter proportionally than either of the quadrangular species.

Quite abundant above the juncture of the Little Cuyahoga with the Cuyahoga river, where it is associated with *L. cuyahoga* and *L. meeki*.

LINGULA GANNENSIS, Sp. n.

(Plate III, Fig. 2, 3.)

Shell elliptically subquadrate, length and breadth as considerably less than two to one (as eleven to six); lateral margins nearly straight and parallel, anterior margin sub-truncate, with rounded angles ; beak rather acute, with a faint (internal ventral) ridge extending forward upon the mesial prominence ; rostral margins nearly straight.

Ventral valve with a prominent beak, the rostral margins meeting at nearly a right angle ; dorsal valve rather shorter and more obtuse. The valves are evenly convex, slightly flattened toward the front by a plane which does not extend to the middle of the longer diameter. The surface of both valves is ornamented by numerous, sharp, concentric striæ. Length of ventral valve 22, breadth 12 mm.

This species resembles in size and form *Lingula punctata*, H., of the Hamilton group but does not share its surface structure. In some respects *L. membranacea*, Win., is similar, but that species is proportionally longer and more strictly quadrate.

From Gann, Knox Co., O., in red ferruginous band in the freestone 50 feet above the river below the dam. In the freestone of the middle division of the Waverly near division III.

LINGULA MEMBRANACEA, Win.

(Plate III, Fig. 4.)

This species occurs about 60 feet above conglomerate II, four miles south-west of Loudonville. It is thus not much above our Lin-

gula gannensis which greatly resembles it. That species, however, is much shorter and has a different surface structure. The surface in the present species is very finely striate and usually also possesses the coarser folds of growth. Length of ventral valve, 20 mm., width 10 mm. Meek's figure of the dorsal valve in the Ohio Palæontology is slightly too oblong and not rounded enough at the front,

LINGULA MEEKI, Sp. n.

(Plate X, Fig. 31.)

Shell of medium size, ovate, rather attenuated toward the beak, greatest width near the front, lateral margins gentle curves, front a regular curve, beak rather prominent, general surface depressed convex, marked with the usual concentric striæ.

Length, 13 mm., width, 7.5 mm.

Different specimens differ in the amount of attenuation of the beak but it cannot be certainly determined which specimens if any are dorsal valves. This form is somewhat abundant in the Cuyahoga valley with *L. cuyahoga*, *L. atra*, etc.

LINGULA WAVERLYENSIS, Sp. n.

(Plate III, Fig. 1.)

Lingula scotica, MEEK, Pal. O. vol. ii., p. 276. Cf. *L. scotica*, var. *nebrascensis*, MEEK, Pal. Neb., p. 158, and *L. scotica*, HERRICK, Bul. Denison Univ. vol. ii., p. 144, also *L. scotica*, DAVIDSON, Carb. Mon. p. 207, Supl.

It is quite obvious that there are two or more forms related to the European *L. scotica* in American rocks. The coal-measure forms vary considerably yet apparently differ from the Waverly specimens. True, the latter are found in the upper third of the series and may be regarded as precursors of *L. scotica*, but they none the less need to be distinguished. The specimens are found in the shale above conglomerate II, with *Orbiculoidea pleurites* with both valves in opposition.

Shell sub-trigonal, compressed; front margin subtruncate, rounded toward the sides which are nearly straight and converge in the ventral valve at an angle of about 120° to the rather acute but not attenuated beak, while the shorter dorsal valve has a bluntly rounded beak.

Surface of both valves covered by minute, numerous regular striæ upon a plane surface; toward the front the striæ may become irregular and similar to the usual markings in the genus; there are also traces of radiating grooves. The striæ are much finer and less numerous than in *L. scotica*. Our specimens exceed in the closeness of the striæ the example figured by Meek. Length of dorsal valve, 20 mm., width of same valve, 19 mm.

Blue shale above conglomerate II, Newark, O.

ORBICULOIDEA PLEURITES, Meek.

(Plate III, Fig. 5, also vol. III, Plate VIII, Figs. 13, 14.)

Shell large, plano-convex, elliptical. Ventral valve in perfect specimens nearly a true ellipse or slightly oval, strongly convex, greatest elevation near the middle, beak sub-terminal or terminal, depressed, length to width as 25 to 22, surface marked by numerous, rather strong concentric lines which may be quite irregular. Dorsal or under valve flat or slightly concave with strictly concentric striæ and marked by a deep oval impression, which extends one-third the diameter of the shell. Length of a large specimen, 25 mm., width, 22 mm., height, 45 mm.

It was long suspected that the large dorsal valves associated with *O. pleurites* were of that species before the discovery of two valves in opposition settled the matter.

Shale above congl. II, Newark and the same horizon near Gann, Knox Co.

PODUCTUS RARICOSTATUS, Sp. n.

(Plate III, Fig. 19; Vol. III, Plate III, Fig. 28, ?)

Ventral valve of nearly the size and proportions of *P. newberryi* in its smaller forms known as *P. annosa*. Sub-quadrate, with regularly arching surface and acutely pointed somewhat projecting and incurved beak, angles acute, sub-elevated, mesial depression slight or none; marked by distant rounded irregular ribs, fine numerous concentric striæ and variable concentric grooves; spines few, scattered. Dorsal valve apparently the same as in the last volume figured as possibly *P. lachrymosus* var; surface plane to a short distance from the margin where rather suddenly reflexed to correspond with the opposite valve,

surface ornamented along this marginal portion as in opposite valve, the remainder only by concentric striæ and folds and the pustules bearing scattered spines. Width. 38 mm., length, 34 mm., convexity of ventral valve, 10 mm.

Near calcareous concretionary zone at Moot's run. It is possible that this is Winchell's *P. dolorosa* which we have not seen. There is reason to suspect that the specimens hesitatingly referred in vol. iii, to *P. lachrymosus*, var. *stigmarius*, H. are extreme phases of the present species.

PRODUCTUS NEWBERRYI, H.

(Plate X, Figs. 24, 35.)

A very large suite of this species from Bagdad, Weymouth, Medina, Lodi, Burbank, and Cuyahoga Falls present a close agreement except that the specimens from the shales are smaller and less fully developed. From *P. semireticulatus* as seen in the coal measures it differs constantly in the less elevated and arched ventral valve and less perfect development of the concentric markings. It seems to differ from the form identified with *P. semireticulatus* in central Ohio. The tubular spines are strong and curved, being most abundant on the ears of the ventral valve.

Length of a ventral valve, 33 mm., width. 47 mm., height of valve, 18 mm.

This species does not seem to descend much below 100 feet below the conglomerate.

PRODUCTUS (NEWBERRYI, var. ?) ANNOSUS, var. n.

(Plate III, Fig. 17.)

Shell sub-quadrate in outline, moderately convex, length somewhat less than the width; ventral valve moderately convex, convexity less than half the length, greatest about half way from the front margin to the moderately elevated arched beak, which projects but little beyond the hinge; a rather shallow, but distinct mesial sinus extends to near the umbo; shell rapidly depressed toward the small upturned ears which are rounded slightly at the extremities; hinge nearly as long as the entire width; surface marked by varicose and rather strong

radiating costæ which bifurcate irregularly and are pustulose by the prominences bearing the long spines, which latter cover the entire surface though much more numerous upon the ears; surface also ornamented by very numerous minute concentric striæ, also in certain conditions of preservation by the usual fine pores; surface rarely also rendered irregular by large concentric folds.

Dorsal valve plane nearly to the margin, then suddenly deflected to apply to the marginal portion of the ventral valve, marked like the opposite valve, but less distinctly upon the plane portion. Transverse diameter of specimen of medium size, 26 mm., length, 21 mm., convexity, 8.9 mm., projection of beak beyond hinge, 2 mm., nine costæ in distance of 1 cm. at front; depression of dorsal valve (nearly at right angles to plane of valve) at front, 6 mm.

A considerable suite of this species was collected at Alexandria, O., in light silicious flags some distance below the concretionary layer at Moot's run, in connection with *P. shumardianus* of the same type as found in the concretions.

In many respects this form resembles *P. newberryi*, Hall. Direct comparison with specimens from the original locality make it advisable not to separate this as a distant species.

PRODUCTUS DUPLICOSTATUS, Win.

(Plate XI, Figs, 26, 29.)

"Shell rather large, with sub-circular outline, ventral valve very ventricose and greatly arched, with steep slopes to the right and left margins, not enlarged at the aperture and entirely destitute of mesial sinus; marked with numerous interruptedly and irregularly striate sinuous ribs, which dichotomize one or twice in the middle region of the valve, and toward the front resolve themselves each into a fascicule of three or four smaller ribs, themselves raised into a wider rib-like elevation around the anterior margin. The tubular spines are scattered over the whole exterior, but become much more numerous at the commencement of the marginal cosate ridges. The whole exterior of the cast is marked also by oblique punctations, which are placed mostly in irregular lines between the ribs. Length,.....1.19, breadth, 1.24, convexity of ventral valve, .58, number of marginal ridges. 15-20."

This species is apparently, frequently identified with *P. cora* to which it has a superficial resemblance. Near conglomerate II, to *P. arcuatus* layer, Knox and Licking Counties.

The ventral valve of *P. duplicostatus* was seen in connection and is nearly flat with a slight depression of the umbonal region but without the sharp flexure near the front seen, for example, in *P. flemingi* which is quite similar otherwise. The surface characters resemble those of the ventral valve, the whole surface being, however, concentrically wrinkled.

PRODUCTUS RUSHVILLENSIS, Sp. n.

(Plate III, Fig. 15.)

Shell small, hemispherical, very tumid but abruptly flexed near the middle so that the outline of ventral valve as seen from the side is formed of two gentle curves meeting at an angle less than a right angle near the middle; length and breadth about equal; hinge nearly equal to greatest width, sides intersecting the ears at nearly a right angle; beak projecting but little beyond the hinge; umbo rather narrow; in larger individuals a slight mesial flattening, but no sinus. Surface marked by few more or less distinct rounded ribs which are irregularly nodose, but simple and tend to disappear near the margin, and by concentric striæ and folds which form strong plications upon the ears; spines very long, as long as the entire length of shell on the ears where they are numerous; surface of the cast sharply pitted and near the beak furrowed longitudinally. Length of medium sized specimen, 10.5 mm., width, 11 mm., height, 8 mm. Number of radiating plicae 20. This species resembles somewhat *P. wortheni* of the Keokuk, but is still more like *P. costatulus* H. from the Chemung. Some forms of *P. lachrymosa* approach quite nearly. Of the described Waverly forms none seem to require comparison except *P. shumardianus* of which the present species is the lineal descendant apparently.

Subsequent study shows the dorsal valves to be rather strongly concave about one-fourth the height of the ventral, then nearly flat except for a gentle depression in the umbonal region and marked by indistinct ribs below and everywhere by concentric striæ and folds.

With *Phillipsia serraticaudata*, *Productus burlingtonensis*, etc. (about 70 feet above horizon of *P. arcuatus*) at Rushville, Newark, Loudonville, etc.

PRODUCTUS NODOCOSTATUS, Sp. n.

Shell of rather small size, sub-circular in outline, only moderately convex.

Ventral valve as wide as long; hinge line equalling seven-tenths the greatest width; ears small, triangular; beak slightly projecting, acutely prominent, sloping sharply to the flat ears, sloping gently to the front margin; surface covered by numerous, coarse, rounded, rarely bifurcating radiating costæ, rendered nodose by equally coarse, concentric wrinkles. A few spines could be detected on the ears in some specimens, but in others they are obscure. If this is a *Productus* it is quite remarkable in its surface marking and also in its slight convexity. Width, 12 mm., length, 11 mm., convexity, 5 mm., or less. We have been unable to compare specimens of *P. morbillina*, Win. which seems to resemble it. From the upper layers at Rushville, about 100 feet above conglomerate II.

RHYNCHONELLA CONTRACTA, H.

(Plate XI, Fig. 21.)

Since the last volume of the bulletin was published, we have had opportunity to compare carefully and minutely specimens in the same state of preservation, preserving both valves, teeth and all details from the Chemung of Chatauqua Co., and the Waverly of Medina Co., and find the most perfect identity of characters. There can be no doubt of the identification. The same species is also doubtfully known from the Cuyahoga shales.

RHYNCHONELLA MARSHALLENSIS, Win.

This is the common species in the middle Waverly, but occurs rarely seventy feet below conglomerate I near Granville, and in Ashland county. Whether this species is but a modification of *R. sappho* must be left undecided. The specimens referred to *R. sappho* in the last paper are more closely allied to the present form than then supposed.

RHYNCHONELLA, Sp.

(Plate XI, Fig. 22.)

We have a small specimen from Lodi which seems to differ from all the Waverly species, though almost a miniature of *R. marshallensis*.

The very convex and broad form with numerous obtuse or rounded plicæ and the flexure at the front all suggest that species.

HEMIPRONITES CRENISTRIA.

The variation seen in this species is extreme and it will not be attempted to carefully illustrate these. Plate II, Fig. 1, illustrates the typical variety at seventy to one hundred feet below conglomerate I. Plate III, Fig. 12, displays the characters of the rounded form encountered above conglomerate II, where it is associated with a deltoid form even larger than that figured. In the shales sharper striations are preserved. Fig. 5, of Plate II illustrates the appearance of the young as seen at Moot's run.

ATHYRIS ASHLANDENSIS, Sp. n.

(Plate III, Fig. 6.)

Closely resembling in ascertainable characters *A spiriferoides* from the Hamilton, but differing in that the mesial sinus of the dorsal valve is less abruptly elevated at the front. Width of dorsal valve, 43 mm., height, 32 mm. Several valves in a more or less imperfect condition have been collected at Moot's run and in Ashland Co.

TREBRATULA (?) INCONSTANS, Sp. n. (Cf. T. LINCKLÆI, H.)

(Plate XI, Fig. 18; Plate III, Figs. 8, 9.)

Shell sub-ovate, broadest below the middle, length less than one and three-fourths the breadth, moderately gibbous, thickness greatest considerably above the middle, lower outline generally distinctly truncate.

Ventral valve gently arched until near the beak where more rapidly curved, greatest width at the hinge margins at nearly one-half the height.

Dorsal valve less arched, most prominent a short distance below the beak, surface with greatest convexity along medium line and curving gently to the sides, angle of beak about 112° , shell punctate, cast with radiating ridges, shell marked by concentric lines of growth. Length of small, perfect specimen, 10 mm., width, 8.5 mm., thickness, 5.5 mm. Largest specimen seen, length 31 mm., width, 24 mm.

Although very constant in form, this species varies greatly in size. The small forms resemble *T. lincklæi*, H. It differs, if at all, in having the anterior truncation rather more pronounced. The resemblance approaches identity.

Moot's run, 70 feet below congl. I, Ashland Co., 70 feet below congl. I, and Lodi, Medina Co.

RHYNCHOSPIRA (?) ASHLANDENSIS, Sp. n.

(Plate III, Fig. 16.)

A small *Rhynchospira*-like species from the horizon seventy feet below conglomerate I, occurs near Lyon Falls, Ashland Co.

Shell small, broadly sub-oval, with the greatest convexity of the valves above the middle, and the beak of the ventral valves produced beyond its fellow, perforate.

Ventral valve with a strong, narrow, mesial elevation proceeding from the beak to the front where it gradually expands, passing into the general surface at the front which is sinuous; lateral surface depressed, beak strongly projecting, length and width about equal, surface marked by about twenty rather abruptly elevated simple ribs, separated by curved depressions. Dorsal valve wider than long, with a shallow mesial sinus which widens below, lateral surfaces convex. Length, 6.5 mm.

As nothing is known of the interior the generic reference is but provisional.

SPIRIFER BIPLICATUS, Hall.

(Plate II, Fig. 8.)

Examination of a large suite of specimens happily removes all doubt as to the position and specific identity of this species. The species has been peculiarly unfortunate in the illustrations hitherto given with the descriptions.

Meek's figure in the Ohio Palæontology is quite unrecognizable. There is comparatively little variation in our series. Meek's description applies well but it is unusual for more than four plicæ to occupy the fold and these are distinctly paired. The mucronate hinge is also constant and forms an easy distinguishing character from *S. striatiformis*.

mis with which it is associated. Our specimens average less than one inch in extreme width. The area of the ventral valve is rather low and arched and striate parallel to the hinge line.

SPIRIFER MARIONENSIS, Shum.

A comparison of *Spirifer marionensis* and *S. biplicatus* is rendered the more necessary because of their close resemblance and importance as marks of given horizons. The following notes are the result of a careful study of a large suite from all parts of the state.

The ventral valve of *S. marionensis* is more evenly and strongly convex and toward the hinge is more uniformly gibbous, it also projects farther over the hinge, thus the beak of *S. biplicatus* seems more acute; the hinge line is more elevated and strongly arched in *S. marionensis*, while in the other species its sides are approximately parallel until the vicinity of the beak is reached, the area is strongly striate perpendicularly in *S. biplicatus*, while in *S. marionensis* there is also an evident transverse system and a thick ridge below; in both species there are long sharp spines upon the hinge angles which may exceed one-fourth the width of the body of the shell; the plicæ are not strongly dichotomous in *S. marionensis* except near the beak, while *S. biplicatus* tends to develop a pronounced dichotomy or grouping in the ribs; the sinus is more distinct and narrower below in *S. marionensis*; the cast in *S. marionensis* is pustulose about the umbonal region while the rostral cavity is more deeply excavated though the teeth seem less prominent; other minor differences are observed in the comparison of the specimens.

The dorsal valves differ in proportions, *S. marionensis* being rather shorter and having in many cases a slight sinus instead of a fold or, at any rate, no prominent elevation toward the front; the fold in *S. biplicatus* is generally well-marked and often high and is further distinguished by the marked dichotomy of the plicæ.

Spirifer marionensis marks a horizon some seventy feet below conglomerate I, and is known to extend along this line from Richland county to the Ohio river at Portsmouth and Sciotoville. Its absolute horizon is not seen in the northern part of the state, but some of the associated fossils seem to occur at the base of the exposure at Lodi with *Sp. biplicatus* and *Entolium aviculatum*. It is not improbable that *S. biplicatus* is a lineal descendant of the older form and it is

found in the southern and central part of the state at from 70 to 100 feet above conglomerate II with no connecting or introducing forms, it also occurs in the Cuyahoga shales from 100 to 150 feet from the top.

SPIRIFER (MARTINIA) TENUISPINATUS, Sp. n.

(Plate II, Fig. 4.)

Shell of moderate or small size, strongly convex and arched, somewhat wider than long, with very short hinge and rounded angles; ventral valve tumid, especially in the umbonal region, with an undefined sinus extending from the produced basal margin half way to the beak; general outline of valve rhombic ovate, the rounded hinge extremities being slightly above the middle of the height; surface marked by numerous (about 20 in adults,) rounded concentric folds and very fine somewhat irregular radiating striae (in the cast), the summit of the folds ornamented by numerous pointed perpendicular spines in one row. The cast is marked by the impression of a median plate extending one-third the height upon the umbo. Height, 19 mm., width, 21 mm.

The species is especially characterized by the very high incurved beak, proportions, and surface characters. From *S. hirtus* it differs in its relatively greater height and larger size. See Plate iii, Vol. iii. In the same way it differs from *S. pseudolineatus*. It is much more nearly like *S. setigerus*, H. from the Chester, from which it is strangely difficult to separate it. The beak is higher, however, and the concentric wrinkles more marked. *Spirifer præmatura* of the Chemung may prove more nearly allied than appears from published descriptions.

[Compare Pal. N. Y., Vol. IV., p. 250, et seq.]

SPIRIFER DELTOIDEUS, Sp. n.

(Plate II, Fig. 7.)

Our material is still too imperfect to make possible a complete characterization of this species referred to on page 45, Bul. Den. Univ. vol. iii., but the examination of additional material leaves no doubt as to the specific difference of the form from *S. striatiformis* and *S. marionensis*. From the last mentioned species it obviously differs in its more triangular outline and rounded ears, as well as its more elevated

and finely striated mesial fold. From *S. striatiformis* it also differs in the two first mentioned particulars.

Shell of medium size, quite gibbous, triangular in outline, hinge equalling the extreme width; anterior margin angulated in the middle, forming with the hinge roughly an isosceles triangle of 45°; hinge apparently not, or but slightly, mucronate. Dorsal valve prominently convex along the longitudinal axis, rather strongly arched; beak moderately prominent; fold triangular, rather high, sides of shell sloping rapidly from it toward the sides. Surface covered by nearly sixty small rounded, persistent striæ, which rarely bifurcate near the front. From eight to ten striæ fall upon the fold which in spite of its prominence (and because of the similar convexity of the valve) is poorly defined. Ventral valve very convex, provided with a deep, triangular, but narrow sinus and sculptured as the dorsal valve. Width of dorsal valve, 37 mm., height, 29 mm.

All our specimens are casts of separate valves in the sandy parts of conglomerate I. There is reason to accept the suggestion made in the last volume that this species forms a link between the *S. marionensis* and *S. striatiformis*.

ALLORISMA NOBILIS, Dekou.

[See Bul. Den. Univ., Vol. iii, p. 71.]

Additional specimens of this fine species enable us to add the following facts:

There is a considerable range of variation. The shortest specimen seen measures 92 mm. in length, 25 mm. in height at the umbo. The beak is strongly incurved and is more produced than represented in Plate X, Fig. 5, of vol. iii. The effect of this is to make the anterior margin somewhat curved and less extended than there drawn. The surface is marked by very fine thread-like concentric striæ as well as the coarser ones and also by the granular radiating striæ characteristic of the genus, the later being rarely preserved.

ALLORISMA CUYAHOGA, Sp. n.

(Plate X, Fig. 34.)

Shell of medium size, quadrately sub-elliptical, the length equal to twice the height, moderately convex; height nearly equal at both ends; posterior margin obliquely truncate, as is the front; hinge mar-

gin slightly concave, front margin nearly straight, curved nearly equally at either end; umbo moderately prominent, beaks incurved over the anterior third; surface evenly convex, post-umbonal slope with a slight secondary ridge, escutcheon and lunule well marked. Length, 39 mm., height at beak, 24 mm. Flags below second fall at Cuyahoga river.

This species resembles *A. winchelli* greatly but is much shorter proportionally and has a very different front margin.

ALLORISMA CONSANGUINATUS, Sp. n.

(Plate XI, Fig. 13.)

Shell rather under medium size, quadrately sub-elliptical, the length equal to twice the height, moderately convex; posterior margin obliquely truncate, short, abruptly rounded below; front margin rather broadly rounded, greatest projection above the middle; ventral margin a broad gentle curve; hinge line nearly straight; umbo very prominent, beak near the anterior third; post umbonal slope sulcate; surface marked by very coarse, strong, concentric folds.

The peculiarity which separates this from all other members of the genus in the Waverly is the narrowness of the posterior portion and the strongly concave post-umbonal surface. From *A. winchelli*, its nearest neighbor, it differs in the fuller and less acute curve of the anterior, which sweeps upward nearly to the hinge.

Shales over congl. II. Length, 25 mm., height at beak, 13 mm., height at posterior margin, 9 mm.

LEIOPTERIA NASUTUS, Sp. n.

(Plate XI, Fig. 30.)

This species closely resembles *L. orton*i and may best be described comparatively. The body is much more oblique and the posterior wing, therefore, much restricted, the anterior ear is prolonged and rounded at the extremity, beak behind the first third, acute. Length, 10.5 mm., height, 6 mm. Bagdad, Medina county, apparently nearly on the same horizon as *L. orton*i.

AVICULA (LEPTODESMA) SCUTELLA, Her.

(Plate V, Fig. 6, Vol. III. Plate IV, Figs. 16, 17.)

[See Vol. III, p. 59.]

Shell small, obliquely semi-oval, hinge-line equalling the greatest length, height and length nearly equal; posterior wing rather large flat, posterior margin slightly concave, nearly at right angles to hinge-line; anterior ear very small, sub-acute, depressed, nearly covered by the acutely projecting sub-anterior beak; umbonal region abruptly convex, rapidly expanding toward the broad lower portion of the shell, which is marked by concentric striæ. Freestone of middle Waverly. Length of hinge, 6 mm., height, 6.5 mm.

AVICULA ? SUB-SPATULATA, Sp. n.

(Plate V, Fig. 11; Vol. III, Plate III, Fig. 6.)

This species which is quite common in the lower part of division iii at Newark seems to differ widely from any associated species and, though its hinge is unknown, its general form associates it with carboniferous species referred to *Avicula*. Shell slightly oblique, forming an angle of about 25° with a line perpendicular to the hinge; hinge short, contained in the height about two and one-half times; posterior wing flat, obtuse, rather small, anterior ear very small almost covered by the sub-anterior beaks; greatest anterior projection of anterior margin near the middle of the height, posterior outline gently concave above, convex below; surface slightly convex, grooved and striate.

Length of hinge, 85 mm., oblique height along umbonal prominence, 21 mm., greatest length, 15 mm.

EDMONDIA SULCIFERA, Sp. n.

(Plate V, Fig. 1, 2.)

This fine species is most nearly related to *E. burlingtonensis*, but becomes much larger than the Ohio representatives of that species, the form also is less oval and the anterior hinge angle more prominent.

Shell longitudinally sub-oblong, once and a half as long as high, moderately convex; posterior margin a very slight curve oblique to the rather long cardinal line, which extends in front of the beak to meet the more rapidly curved anterior margin; lower margin nearly

straight, passing by an abrupt curve into the posterior side, more slowly curving to the front; greatest convexity above the middle; umbo prominent, projecting; beak small, close to the hinge, situated about one-fourth from the front; surface with fine concentric striæ and deep equi-distant grooves about fourteen of which occur on a large specimen; hinge with a strong posterior tooth.

Moot's run, seventy feet below congl. I.

SPHENOTUS CONTRACTUS, W. W.

(See Vol. III, p. 69.)

Winchell in 1865 identified this species with his own *Edmondia bicarinata*. Originally this species was supposed to have come from the equivalent of the mill-stone grit. Cf. also *Cypricardia securis* Win. Proc. Acad. Phila. 1870, p. 255.

GENUS SPATHELLA. H.

"Shell equivalve, inequilateral, wider behind, transversely sub-cylindrical. Anterior end short, narrowly rounded. Beaks sub-anterior, small. Umbonal slope rounded or sub-angular. Surface marked by concentric striæ, which are often more or less lamellose. Interior unknown."

SPATHELLA VENTRICOSA, W. and W. ?

(Plate IV, Fig. 20.)

Our specimens do not fully agree with the figures of "*Orthonota ventricosa*," but there seems to be a considerable range of variation, and as that species occurs in the Kinderhook group of Illinois, it seems likely that ours is closely allied if not identical.

Freestone of middle Waverly.

MYTILARCA FIBRISTRIATUS, W. and W.

(Plate IV, Fig. 21.)

The original description reads as follows :

"Shell elongate oval, alternate at the beaks, more ventricose below, extremely compressed toward the extremity of the hinge and posterior margin. Beaks terminal, small and pointed; hinge-line straight,

about half as long as the shell. Postero-dorsal margin gently curved toward the sharply-rounded posterior extremity; ventral margin gently arcuate, more strongly rounded toward the beaks, a little below which the ventral surface is somewhat protruded and the margins slightly gaping, forming a distinct byssal opening. Surface marked by fine, closely arranged, radiating striæ, which become faint or obsolete on the antero-ventral portion."

Moot's run, 70 feet below conglomerate I.

MYTILARCA OCCIDENTALIS, White and Whitfield ?

(Plate XI, Fig. 1.)

The description of this species is, like most of those in the paper referred to, very equivocal, without measurements and almost devoid of comparative proportions.

"Shell extremely elongate, very ventricose, the diameter through the valves on the upper third of the shell as great or greater than the breadth from the ventral to the dorsal margins, becoming more compressed toward the posterior, which is abruptly rounded. Dorsal line nearly straight, extending about two thirds the length of the shell. Ventral margin gently acute to near the anterior where it slopes abruptly to the beaks. Beaks terminal, obtusely pointed, umbonal prominences sub-angular. Surface marked by closely arranged, concentric lamellose lines, parallel to the margin of the shell."

Our species differs from *M. fibristriatus* in being more expanded above the umbonal prominence posteriorly, the hinge being longer and the greatest posterior projection lower. Length, 47 mm., height, 17 mm. Medina county, O.

LYRIOPECTEN NODOCOSTATUS, Sp. n.

(Plate XI, Fig. 5.)

Shell large, longitudinally broadly elliptical; height somewhat less than the length, margin regularly rounded. Valves similar; right valve flat. Hinge-line straight, length over two-thirds the entire length of the shell. Anterior ear small, somewhat acute, rather indistinctly marked off from the valve, but apparently without deep byssal sinus; anterior ear much larger and well defined. Surface marked by about

45-50 strong very nodose radii separated by a shallow groove and one, or occasionally two, unornamented ridges.

Our specimens are all imperfect, but a nearly complete right valve indicates that the outline must agree closely with that of *L. interradians*, H. from the Hamilton group, with which it agrees in size. The surface structure serves to distinguish it from other members of the genus. Height, 37 mm., length, 43 mm.

Concretionary zone about seventy feet below conglomerate I, in Licking and Richland counties.

PTERINOPECTEN CARINIFERUS, Her.

(Plate V, Fig. 12.)

Additional specimens show that the form of the left valve is inconstant in one particular. The anterior ear occasionally does not correspond to its fellow in outline but is continued from the anterior extremity of the hinge nearly at a right angle to point of union with the body. The ear therefore is nearly a right-angled triangle, but is marked by the impression of the margin of the corresponding ear of the right valve. This must be regarded as the typical form, but is rarely seen as in most left valves the byssal sinus is well-marked. Length, 17 mm., height, 14 mm., distance between radiating striae nearly 1 mm.

This species is quite abundant in Ashland Co., about seventy feet below conglomerate I, and also occurs at Lodi in the concretions at the very base of the exposure.

PTERINOPECTEN (?) ASHLANDENSIS, Sp. n.

(Plate XI, Fig. 4.)

Known only from fragments of the left valve. Shell triangularly sub-elliptical in outline, somewhat oblique, length somewhat greater than the height. Umbonal region narrow, acute, depressed, body rapidly expanding toward the front, ant-umbonal margin concave, long; anterior ear unknown; front margin a gentle curve; post-umbonal margin straight; posterior ear small, flat, obtusely triangular. Surface depressed convex, ornamented by about fifty irregular wavy ribs in pairs, separated by narrow impressed grooves, which are crossed by

concentric, more or less wavy grooves and striations. Length, 25 mm., height, 23 mm.

It is not possible to strictly define this species but it is sufficiently distinct from any of the associated species.

Concretionary shale seventy feet below conglomerate I, near Lyon Falls, Ashland Co.

CRENIPECTEN CANCELLATUS, Her.

(Plate V, Fig. 3.)

[Vol. III, p. 54, Plate XII, Fig. 7.]

Full-grown specimens of this species are less orbicular, and the right valve makes it obvious that our species is not a *Lyriopecten* but probably *Crenipecten*, though the hinge is still unknown.

Right valve closely resembling in outline that of *Streblopteria media*, but less convex and with a larger posterior ear. Surface marked, as in the opposite valve, by sharp, fine, and very numerous concentric and radiating striæ, the radiating striæ becoming very coarse on the anterior.

CRENIPECTEN CRENISTRIATUS, Meek.

(Plate V, Fig 14.)

A considerable suite of specimens permits little doubt that the various forms of large Pecten-like shells of the upper Waverly all belong in the assemblage named as above by Meek. We have not indeed encountered any individuals with the outline as drawn in the Ohio Palæontology, but although these figures are not expressly said to be restorations, yet that this is the case is implied in the following remarks: "It is remarkable in having only a comparatively shallow rounded sinus under the anterior ear of the flat right valve, where it is usually deep and angular in species of this genus, while in the left it is deeper and more angular, *though none of the specimens are in a condition to show its exact form.*"

Considerable variation is encountered in shells from different horizons. Those found only a few feet above conglomerate II most nearly resemble the figures of Meek, but the left valve has the posterior ear more strongly produced and larger, while the anterior ear is much larger and the margin below the sinus is produced and abruptly angu-

lar, instead of gently curved. Specimens from about 100 feet above conglomerate II have much larger posterior ears but otherwise remain nearly the same. The right valve does not usually have the exceptional form referred to by Meek but possesses the usual strong sinus under the anterior ear. The surface of the valve is less strongly marked than the left which is exquisitely ornamented with alternate radiating and keeled concentric striae. As we have already proposed the term *granvillensis* for the form first above described, we may suggest *rushvillensis* for the second, since it is there abundant at the top of the exposure. These may be regarded as named varieties or formæ.

GRAMMYSIA OVATA, Sp. n.

(Plate III, Fig. 12)

Shell of medium size, quite ventricose, convexity being considerably greater than the height, and greatest tumidity near the umbo length to height as 85-45; general outline sharply ovate, acute posteriorly; anterior margin short, with a deeply impressed lunule; hinge margin gently curved, escutcheon well defined; lower margin a long sweeping curve passing by a sudden flexure into the dorsal margin produced; beaks incurved almost over the anterior margin; surface striate. Length, 40 mm., height, 23 mm., ventricosity, 26 mm.

Upper part of division III, Newark, etc

GRAMMYSIA FAMELICA, Sp. n.

(Plate VI, Fig. 5.)

Shell apparently never attaining medium size for the genus, sub-oval in outline, moderately convex; height to length as 11 to 15; greatest convexity near the upper third; beaks very prominent, incurved, situated rather more than one-third the length from the front margin; lower (basal) margin a very shallow curve, meeting the obliquely truncated posterior margin rather acutely and curving more rapidly to the intersection with the anterior margin at about one-half the height of the shell; anterior margin nearly straight or somewhat concave; the escutcheon not distinct, lunule distinct, though short; beak enrolled over the hinge-line which is less than one-half the entire length; post-umbonal slope scarcely defined. Surface marked by

thread-like striæ and rather coarse folds which are most prominent as they cross the antero-umbonal slope. Length 30 mm., height 22 mm., convexity of one valve, 7-9 mm.

This species is unusually short and Schizodus-like and may not be a Grammysia, though doubtless falling in the same group with the Waverly species referred doubtfully to that genus by Meek.

Shale below conglomerate I, Granville.

SCHIZODUS (CHEMUMGENSIS, var.) PROLONGATUS, Sp. n.

(Plate VI, Fig. 1, also Plate IX, Fig. 20, vol. iii.)

It is only in deference to the opinion of able palæontologists that this form is separated from the typical *S. Chemungensis*, from which it differs almost solely in being generally somewhat more extended at the postero-basal angle and hence having somewhat more oblique posterior margin. There may or may not be a faint sinus passing upward from a point slightly forward from the posterior angle. Length, 33 mm., height, 24 mm.

This form is not rare in shales below conglomerate I, at Granville.

SCHIZODUS NEWARKENSIS, Herriek.

(Plate VI, Fig. 6.)

A number of additional specimens of this our largest *Schizodus* afford opportunity for ascertaining the typical form. As supposed, the original specimen proves to have been considerably distorted, but the species is quite distinctly characterized by the uniformly curved anterior margin which forms nearly a segment of a circle and the convexity of the surface near it as well as the obliquely protruded postero-inferior angle and large size. In outline the species somewhat resembles certain forms of *Sc. chemungensis*, which, however, never attains anything like the size of the present species. Length, 80 mm., height, 60 mm. Length, 82 mm., height, 64 mm.

MACRODON NEWARKENSIS, Sp. n.

(Plate IV, Fig. 19.)

Shell of medium size, rather flat, sub-oblong, about twice as long as high, basal and cardinal margins parallel, the former gently con-

vex throughout, not affected by a sinus medianly as usual in the genus; hinge-line shorter than the shell; posterior side slightly oblique forming an angle of about 100° with the hinge; anterior margin apparently meeting the hinge at nearly a right angle; surface depressed posteriorly but elsewhere gently and nearly uniformly convex, marked by both radiating and concentric striae, the former consisting of minute wavy lines on the post-umbonal space, four or five strong costae on the umbonal prominence and passing to the postero-inferior angle, and very fine, straight, close radii on the remainder of the shell, the whole being delicately and finely cancellated by concentric striae.

Perhaps this species most nearly resembles *M. tenuistriata* of the coal-measures, from which it differs in lacking the sinus below, in the surface markings and outline.

A similar but smaller form is figured by Hall from Bedford, O., but seems to agree with *M. hamiltoniae* in markings.

M. chemungensis possesses the sinus and differs in markings. The resemblance to *M. micronema*, M. and W. * is much more striking apparently, but our shell is larger and less extended. Length 33 mm. height 17 mm. Length of another specimen 41 mm.

Near Newark, O., about 60 or 70 feet above congl. II in our division III.

MACRODON STRIATO-COSTATUS, sp. n.

(Plate VI, Fig. 7; Plate XI, Fig. 37.)

Cf. *Macordon parvus*, W. and W.]

A small Macrodon of the same group as *M. newarkensis* is found in shales seventy feet below conglomerate I, in Ashland Co. It is, however, a smaller species and does not have the enlarged striae, on the post-umbonal ridge.

Shell small, transversely semi-elliptical, a little broadest posteriorly, hinge nearly equalling the greatest length; beak about one-fourth from the front, somewhat prominent; anterior outline a gentle curve, beginning at the hinge with a little more than a right angle, it curves more rapidly as it enters the ventral margin which is more or less convex; posterior outline somewhat concave; surface convex about the umbonal region, quite flat posteriorly, marked by strong concentric

*Proc. Acad. Nat. Sci. Phila. 1886, p. 201.

furrows and numerous radiating striæ. Length, 8 mm., height, 16 mm.

Specimens from Licking and Ashland counties agree quite perfectly.

MACRODON, Sp.

Plate XI, Fig. 28.)

A small species resembling *M. delicatus* of the coal-measures differs from all other Waverly species in the strong radiating markings confined to the posterior two-thirds, while the anterior part of the shell is nearly devoid of them. Our specimen is too imperfect to admit of description as the hinge-line appears to be covered or broken away, but the occurrence of the species with *Spirifer marionensis* at Portsmouth should be noted.

CYPRIGARDINIA (MICRODON ?) SCITULA, Sp. n.

(Plate VI, Fig. 8.)

Shell very small, tapezoidal, highest behind, somewhat convex. Anterior margin short, concave, forming with the hinge an angle of about 120° ; hinge-line straight, about two-thirds the length; posterior margin nearly straight, meeting the hinge at an angle of over 135° , abruptly curved below; lower margin slightly convex, straightened in old specimens near the middle. A strong, curved ridge passes from the sub-terminal beak to the postero-inferior angle, middle of valve with a shallow sinus passing to the lower margin in old specimens. Surface ornamented by distant sharply, elevated, rib-like concentric ridges and grooves. Length of largest specimen, 10 mm., height, 5.0 mm. Average specimen, 7 mm. long.

CARDIOPSIS (DEXIOBIA ?) OVATA, Hall.

(Plate IV, Fig. 6.)

Dexiobia whitei, WIN.

This species has a curious history of which our specimens do not permit us to attempt the concluding chapter. It was described by Prof. Hall in his Iowa report from the Kinderhook group at Burling-

ton, in the following terms: *Cardiomorpha ovata*. "Shell ovoid or subcordiform; valves ovate, slightly oblique, a little longer than wide. very gibbous in the middle and toward the umbo; beaks extended and incurved. Surface marked by numerous fine radiating striæ."

In the Proceedings of the Boston Society of Natural History, Mr. C. A. White described *Cardiomorpha parvirostris* as follows: "Shell sub-circular in outline, slightly inequilateral; valves broadly and moderately convex; base more broadly rounded than the front and oval margins; beaks small, incurved, pointing little, if any, forward. Surface marked by fine radiating lines."

In the meantime Meek and Worthen in Proc. Acad. Nat. Sci., Phila., 1861, (afterwards also in volume ii of the Palæontology of Illinois) had founded the genus *Cardiopsis* upon a species from the same horizon with the following diagnosis: "Shell equivalve, somewhat inequilateral, very slightly oblique, ovate or cordiform, entirely closed; beaks rather elevated, distinctly incurved and directed toward the anterior side; surface marked by radiating striæ or costæ; cardinal margin short and rounding into the posterior border, hinge provided with one or two distinct anterior teeth in each valve, near the beaks."

To the original species *C. radiata*, Prof. Winchell added three more in 1862, (Proc. Acad. Phila., p. 417.) *C. crenistriata* differs from *C. radiata* "only in its striation," and seems to have been reunited with that species by its author, and is omitted from the list published in 1870. *Cardiopsis megumbonata* scarcely differs and suggest that *C. radiata* may exhibit considerable variation. *C. jejuna*, the remaining species, seems quite distinct.

In 1863 Prof. Winchell formed the genus *Dexiobia* (*dexios-bia*) to receive *D. whitei* (= *C. ovatus* + *C. parvirostris*, which he identified as the right and left valves respectively of the same shell) and another and quite different form, *D. halli*, which is possibly identical with Prof. Hall's *C. rhomboidea*. The diagnosis of the genus is as follows: "Shell thin, inequivalve, inequilateral; beaks separated by an undefined area. Right valve very ventricose, with a prominent umbo, and a produced, incurved beak, strongly inclined forward. Left valve much less inflated, with a less prominent beak, scarcely elevated above the dorsal margin. Hinge-line more or less extended, straight, or slightly bent, edentulous (?) furnished with a thickened cartilage plate bearing a linear posterior groove. Pallial line and muscular marking unknown."

The two species associated in this genus differ so greatly that it may be seriously doubted if they can continue in the same genus.

Unfortunately for the comparison, the right valve alone of *D. halli* appears to have been found, thus leaving open the question as to its being inequivalve. The hinge-line is straight and produced in this species, while it is quite inconspicuous and curved in *D. whitei*. The greater number of characters of *Dexiobia*, however, apply better to the second species, though in that case the name, as it proves, is less applicable, some at least, of the species being nearly equivalent.

In this predicament the best that can be done seems to be to regard "*C. ovata*" as the type of the genus *Dexiobia* with somewhat limited characters, even though strongly suspicious that that species properly belongs under *Cardiopsis*. The remaining forms from the Waverly must then constitute a new genus.

A considerable suite of specimens, all from the upper part of the freestone enables us to prepare the following description.

Shell of medium size, obliquely ovate in outline, quite convex, asymmetrical. Right valve generally somewhat higher than long, variable, triangularly ovate, very gibbous; anterior margin evenly rounded; lower margin gently curved or somewhat straight; posterior margin more acutely rounded, passing obliquely into the short hinge-line which bears the impress externally of two teeth, one being anterior the other posterior; beak very prominent, acute, extending above and arching over that of the opposite valve; greatest convexity about at the middle of the surface which falls off rapidly in all directions; surface ornamented by nearly sixty rounded costæ and irregular concentric striæ and folds. Left valve obliquely ovate, produced posteriorly, slightly convex, with a short, obtuse beak; post-umbonal plane at right angles to the valve; surface marked as in the other valve. The valves meet closely. Greatest height 20 mm, length 18 to 20 mm. About 16 costæ to a centimeter in a specimen 20 mm. high; in smaller specimens twice as many.

It is indeed possible that two species are represented by our specimens. The greater number resemble *Cardiopsis radiata* in the surface markings but are certainly inequivalve and resemble *D. ovata* in outline more nearly than *Cardiopsis*. If *Cardiopsis* should be found to be inequivalve it would relieve us of the necessity for the additional generic term. The fact that the two forms are derived from the same horizon is suggestive.

GENUS ORACARDIA. Gen. n.

Dexiobia, WINCHELL (pars. ?) (*Ety.* oraio-kardia.) Type *A. ornata*,

Shell somewhat inequilateral, more or less inequivalve, both valves quite ventricose, with a strongly curved, acute, elevated beak, which inclines forward at the apex. Hinge-line extended, produced posteriorly, furnished with a thickened ridge or cartilage plate. The beaks are separated from the hinge by a pseudo-area which is elevated and more or less arched under the beak.

Surface marked by radiating lines which do not tend to increase in number toward the front.

ORACARDIA ORNATA, sp. n.

(Plate IV, Fig. 8, 9, 10.)

Cf. *Dexiobia halli*, WIN.

With the characters of the genus. Shell transversely semi-elliptical, somewhat oblique, hinge-line as long as the shell, straight; beak acute, oblique, recurved, elevated; anterior slope concave, flattened, producing a double ridge, posterior slope more regular, convex or flattened; greatest convexity at about one-third the height from the beak, front portions curving very abruptly to the broadly curved lower margins; anterior margin meeting the hinge by a gentle curve. Surface marked by rounded distinct ribs which are closely set and continue for the most part from beak to lower margin, also by irregular concentric folds.

The area is acute below the beak. Judging from our specimens the right valve is somewhat more convex than the left but not remarkably so. Height of a left valve, 22 mm., length, 27 mm., convexity 9 mm., six striæ occupy a distance of 5 mm., at the lower margin. Several specimens were found near the top of the freestone of middle Waverly. A very small specimen apparently of this species was obtained 108 feet above conglomerate I in Richland Co. *Dexiobia halli*, and *Cardiomorpha rhomboidea* may both refer to this species, though the description of the latter is insufficient and the former is said to be smooth.

ORACARDIA CORNUTA, sp. n.

(Plate IV, Fig. 6.)

Shell small, body subquadrate or semi-oval. Right valve (alone known) with the body nearly quadrangular but enormously produced at the umbo, to form the very high, strongly coiled beak which extends half the height of shell above the hinge, which is straight, equaling the greatest length and bears the impress of the usual cartilage plate or ridge. The surface of the cast bears traces of numerous radiating and concentric striæ. The shell might at first be taken for a *Platyceras* if the hinge were overlooked. Height, 11 mm., length, 9 mm.

Immediately below congl. I with *Palæoneilo elliptica*,

CONOCARDIUM ALTERNISTRIATUM, sp. n.

(Plate XI, Fig. 24 ; Plate V, Fig. 7. ?)

Of medium or large size for the genus, rather strongly convex. Lateral surface composed of two facets or curved, triangular planes separated by a more or less well-marked depression or groove, of these the anterior is strongly convex to the incurved beak, is about twice as wide as high and marked by about ten distant ribs which are separated by intervals wider than the ribs, both the depressions and the tops of the ribs being plane; the posterior portion of the surface is less convex and longer than high and is marked by over twenty closely set and very irregular ribs, there is a tendency to alternation but frequently two or three of the smaller costæ separate those of the larger set; the ant-umbonal surface is heart-shaped in outline and rather strongly concave to near the projecting tubular projection, where it is strongly reflexed, marked by 12-14 rather closely set arching ribs. Surface finely marked by concentric striæ especially between the ribs.

All the specimens of this fine species seen were more or less distorted as is usual in this genus, hence it is not safe to rely too implicitly on proportions as seen in any specimens.

Height of small specimen, 15 mm., length from umbonal ridge to posterior, about 16-18 mm., convexity of both valves, about 10 mm. Height of a larger specimen along umbonal ridge, 24 mm.

Bagdad and Burbank, Ohio, above the concretionary shales of Lodi.

There is no species known to us sufficiently resembling this one to require comparison.

GENUS PALÆONEILO.

Much yet remains to be done in the way of comparative study of these perplexing forms of which our material is far from satisfactory. We are inclined to withdraw the name *Goniodon*, provisionally used for some of these forms, though *G. ohioense* can hardly enter any of the genera as now limited. The hinge, however, probably had true teeth in an uninterrupted series. Our series begins in the Bedford shales in northern and central Ohio, with a species of *Palæoneilo*, called by Meek, *P. bedfordensis*, but which is very closely allied to Hamilton *P. constricta*. Something over one hundred feet higher we find our *P. consimilis* which somewhat resembles in outline *P. maxima* of the Hamilton.

PALÆONEILO CONSIMILIS, sp. n.

(Plate IV, Fig. 14.)

Very similar to *P. bedfordensis*, but more elongate. Sub-ovate, produced posteriorly; length to height as 17 to 12; basal margin very convex opposite the beaks, curving regularly toward the front but straightened, almost sinuous, toward the narrowed posterior extremity; hinge declining from the beaks, which are near the anterior third; surface rather flat with an obscure sinus posteriorly, marked by very fine concentric striæ. Length, 17 mm., height, 11 mm. This species connects *P. bedfordensis* with *P. ignota* and does not greatly differ from the extremely elongated varieties of *P. constricta*.

When describing *P. bedfordensis* Mr. Meek refers to *P. brevis* of the Chemung as its nearest ally. Had he, however, compared it with *P. constricta* he might have hesitated to distinguish it. Compare, for example, our Fig. 8, Plate IX, with Fig. 3, Plate XLVIII, Vol. V, Pal. N. Y. The only difference appears to be the bolder sweep of the anterior outline in *P. bedfordensis*.

Near Harlam; Delaware Co., O.

PALÆONEILO IGNOTA, sp. n.

(Plate IV, Fig. 15.)

Shell of medium size, moderately convex, rather thick, height two-thirds the length, the greatest height a little posterior to the beaks which are one-third the distance from the front, basal margin semi-elliptical, terminating before and behind at nearly one-half the height; anterior margin sub-parabolic; posterior outline rather acutely terminating at about one-third the height from the somewhat oblique hinge; posterior projection compressed; surface most ventricose near the middle, marked only by very fine, numerous, crowded concentric striæ. Hinge with five moderate teeth in front and fifteen or more very fine denticles behind which diminish toward the beak.

The shell could easily be mistaken for a *Nucula* (*Ctenodonta*) as frequently used but is obviously related to the group of *Palæoneilo*, found in the Chemung. Length, 14 mm., height, 9 mm.

Moderately abundant in Nodules at Moot's run, Licking Co.

This species bears some resemblance to *P. bedfordensis*, Meek, but is not sinuous or greatly compressed posteriorly.

PALÆONEILO (NUCULA ?) CURTA, sp. n.

(Plate IV, Fig. 4.)

Quadrangularly sub-oval, moderately convex, hinge and front margins sub-parallel; posterior margin evenly rounded, anterior margin acutely angled, lunule strong; beak one-fourth from the front; hinge in front of the beak with five or six small teeth, behind with seven stronger denticles. Length, 11 mm., height, 6.5 mm. Freestone of middle Waverly.

PALÆONEILO SULCATINA, Win.

(Plate IV, Fig. 17.)

Quite common forty feet below conglomerate I, Union, Licking county.

NUCULA (CTENODONTA) HOUGHTONI, Stev.

(Plate IV, Fig. 3; Plate X, Figs. 4, ?.)

This species in several minor varieties seems to extend from the

middle to well into the upper third of the Waverly. The figures on plate four represent specimens from a horizon forty feet below conglomerate I, that on Plate X, from Cuyahoga Falls.

NUCULANA, sp.

(Plate IV, Fig. 12.)

A small species known only from imperfect casts differs from all other Waverly species in the outline. The anterior portion is very short and abruptly rounded. The hinge margin is straight and oblique to the axis of the shell. Posterior portion short and acute; surface moderately convex. Length, 9 mm., height, 5 mm., beak about 2 mm. from front.

Williams quarry, Granville. Freestone.

NUCULANA NUCULÆFORMIS, Stevens ?

(Plate IV, Fig. 23.)

Opportunity has not presented for careful comparison with authentic specimens of this species hence our identification is provisional. Found associated with *Ctenodonta houghtoni* above conglomerate II at Newark. Length, 18 mm., height, 10 mm.

NUCULANA, sp.

(Plate IV, Fig. 11.)

This is the characteristic species of this genus in the freestone, but the material is too imperfectly preserved for description.

FLEMINGIA (?) STULTUS, sp. n.

(Plate VII, Fig. 10.)

Shell small, acutely conical; spire composed of five whorls, obliquely flattened along the dorsum to produce a plane conical spire with sub-carinate suture; surface of cast unmarked. Diameter of lower whorl, 10 mm., height of spire, 11 mm. The body whorl is strongly angulate along the free side and slopes rapidly to the umbilicus which with the aperture is unknown. A single specimen from

the freestone of the middle Waverly is thus named because of the conical spire resembling a fool's cap.

Since writing the above a number of specimens imbedded in the freestone near the top of division II have been collected. These specimens seem to prove that our species is a trochoid shell and not a Pleurotomaria. No evidence of a peripheral revolving band or of a notched outer lip can be observed, while the strictly conical spire and angulated lower margin of the body whorl and what can be seen of the lip suggest *Flemingia*. The spire is often higher than in the specimen drawn and the outer surface of the volutions somewhat convex, but never in either respect equalling *Flemingia turbinato-conica* of DeKoninck. It may be compared with *F. coniformis*, Dek. There are usually four whorls which are marked in the casts only by the impressed lines of growth. The aperture is not well preserved but seems to be lenticular. The umbilical surface of the lower whorl forms nearly a right angle with the spire.

Height of spire in largest specimen, 13 mm., diameter of largest volution, about 12 mm. Other specimens are only 4 mm. high, and equally broad.

PLEUROTOMARIA TEXTILIGERA, Meek.

(Pal. O., Vol. II, p. 314.)

This pretty species is quite common at Bagdad, and occurs also at Lodi on a slightly lower horizon. It has not been found in the central or southern part of the state.

PLATYCERAS LODIENSE, Meek.

(Plate XI. Fig. 2; Plate VIII, Figs. 1 and 7.)

We have specimens from Bagdad which may represent this species if Meek's description was prepared from a young or imperfect specimen. Much variation is permitted within species of this genus. The following added particulars are noted:

The shell though never spirally coiled may be considerably arched and restricted at the tip or it may be nearly straight above the posterior margin of the aperture. The carina of the anterior surface (in the cast) does not reach the aperture in large specimens but terminates by a triangular attenuation. Near the aperture the sides are

more or less plicate. The apex of our specimens resembles Meek's figures.

ORTHOCERAS HETEROCINCTUM, Win. ?

The specimens referred to this species are all fragments and are insufficient to fully determine the identity.

Shell unequally annulated, tapering rather rapidly, section sub-circular, siphuncle central (?). Chamber of habitation very long, annulated irregularly, annuli rounded, separated by shallow concave grooves. Septa slightly oblique, distant about one-fourth the diameter or less; septate portion very irregularly or scarcely annulated; surface marked by close, concentric, raised striæ. Transverse diameter, 12 mm., chamber of habitation, 38 mm., distance of septa, 3 mm.

Lodi and Burbank, Ohio.

GYROCERAS, sp.

A species apparently of this genus with close resemblance to *G. Rockfordensis*, M. & W. is found in the upper division, perhaps seventy feet above conglomerate II. It seems rather larger than the species quoted, but in general characters, so far as known, is similar.

CONULARIA VICTA, White. ?

(Plate VIII, Fig. 3.)

WHITE, Proc. Bost. Soc. N. H., vol. IX, p. 22.

Shell square-pyramidal, moderately acute, uninclined, with the sides nearly equal, and moderately convex, inclined to each other by about 15 degrees. The angles are marked by the usual grooves, into which the striæ pass without abrupt downward flexure, meeting nearly directly, while the middle of the lateral faces bears an ill-defined suture (which is rather the intersection of two synclinal planes of the surface than a groove) where the striæ meet at rather large angle and generally in opposition rather than alternately. The inclination of the striæ is such that at the median groove the striæ are nearer the aperture by the width of from five to seven striæ than at the angles. The surface is marked by very numerous, acutely ridged striæ, of which there are 28 to the centimeter or 70 to the inch, these striæ were sharply ridged or keeled but apparently not crenulated, groove separ-

ating the striæ narrow, rather shallow, unornamented. Length of specimen 45 mm., width near the base about 14 mm.

From *C. micronema*, which it most resembles, this species differs in the greater coarseness of the striæ which are hardly half as numerous, and especially by their sharp curvature toward the aperture thus intersecting more acutely at the median groove.

The species may be compared with *C. sub-carbonaria* of the Keokuk group but obviously differs in several characters. Unfortunately our specimens do not preserve the surface sufficiently to make the absence of sculpture certain, while the figure has been restored as to the aperture and must not be too fully trusted in that respect. Other specimens differ from that figured in the less acute intersection of the striæ at the median suture and seem to have a minute pearly of the summits. The number of striæ varies from 45 to 70 in one inch.

Associated with *C. newberryi*, in the upper division from 50 to 100 feet above conglomerate II, Newark, Rushville, and near Loudonville.

CONULARIA GRACILIS, sp. n.

(Plate VIII, Fig 2, also Plate VI, Fig. 13, vol. iii.)

In our discussion of *C. newberryi* in the last volume the differences existing between the *Conularias* of various horizons were referred to, especially in the case of the form found at Moot's run and elsewhere, at a distance of seventy feet below conglomerate I. This form is now represented by abundant material and proves to be a very distinct and remarkable species. *C. newberryi* itself seems only to occur above conglomerate I, being abundant in shales just below conglomerate II and in division III. It is found in the Cuyahoga shales and seems to attain the coal-measures. The present species may be defined as follows:

Shell quadrangular, extremely elongate with nearly parallel sides, attaining a length of five inches or more. In a specimen 18 mm. wide at the base there are eight ridges in one centimeter but they vary with their position and size of the specimen. Lateral surfaces flat with but a faint median suture, while those of the angles are well defined. The summits of the ridges are ornamented by closely set bars parallel to the length of the shell which are strictly limited to a zone bordered by a depression on either side. The ridges arch gently. Mouth with well developed lips. (See Plate VI, Vol. iii.)

Moot's run, and near Loudonville, 60 to 80 feet below conglomerate I, also at Alexandria, O.

CONULARIA MICRONEMA, Meek. var. n.

(Plate VIII, Fig. 4.)

Shell square-pyramidal, moderately acute, uninclined, with the sides nearly equal, nearly plane or gently convex, inclined to each other at an angle of about fifteen to eighteen degrees. The angles are marked by the usual groove into which the striæ pass by a very sudden flexure, while the middle of the lateral faces bears a definite though narrow groove, across which the striæ do not pass. The surface is marked by very numerous, closely crowded, thread-like, gently curved striæ of which there are 60 to the centimeter or about 150 to the inch; these striæ are ornamented by pyramidal prominences which are separated by a distance less than the interval between consecutive striæ.

CRUSTACEA.

Considerable attention has of late been paid to the trilobites of the Carboniferous and immediately preceeding formations.

Beginning with a brief synopsis by the writer in May, 1887,* and a description of a perfect specimen of *Phillipsia auriculata*, there followed in the same year Lieut. Vogdes' "Genera and species of N. A. Carboniferous Trilobites," and in the next year, in April, a description of *Phillipsia (Proetus) Præcursor* in Bul. Den. Univ. vol. iii, and a little later the last volume of the Palæontology of New York in which are discussed a large number of Devonian and Carboniferous species.

One or two points in Mr. Vogdes' valuable paper should be noted. For example, on page 81, in quoting *Phillipsia trinucleata*, Herrick, he refers to it as from the Waverly instead of a well-authenticated coal-measure horizon. Influenced apparently by this impression the

*"Synopsis of Carboniferous Trilobites" forming appendix I to the first installment of the present article entitled "Carboniferous Fossils, from Flint Ridge, Ohio." This paper has been quoted by continental reviewers as by Mr. Flint Ridge, Esq., illustrating at once the illusory character of fame and the care bestowed by trans-atlantic authors in dealing with American papers.

species is referred to the genus *Proetus* to which it can hardly be assigned upon any of the various definitions of that genus.

The case of *Proetus missouriensis*, Shum. is likewise somewhat confused. *Proetus auriculatus*, H. is said to extend from the Chemung into the Waverly group, while as a matter of fact it was originally described from Granville, O., where our author states *P. missouriensis* is found. Though originally referred to the Chemung these strata are typical Waverly. Prof. Hall, moreover, identifies his species with *P. missouriensis*. Nevertheless Mr. Vogdes states that in specimens from Cameron, Missouri the "genal angles *appear to be* obtusely rounded off," and they are so drawn. Certainly the head figured on Plate III, of that paper differs widely from that drawn by Meek, which is copied for comparison, and is totally unlike the Ohio specimens in the character of the movable cheeks.

Prof. Hall in his last report insists that this species is a *Proetus* though recognizing the specific identity of Missouri and Ohio specimens. The question is largely one of individual opinion as to the limits of the two genera. Though the writer would prefer to restrict the application of the name *Proetus* to species of the group of *P. bohemicus*, Corda, reserving those with large basal lobes and but two distinct furrows upon the glabella and longer head-shield for the genus *Phillipsia*, the question must be decided by the consensus of palaeontologists.

The catalogue of Mr. Vogdes as thus corrected includes from the Waverly the following five species of *Proetus*: *P. auriculatus*, *P. loganensis*, *P. peroccidens*, *P. ? ellipticus* and *P. tennesseensis*, but it is still uncertain how far the Wahsatch strata referred to the Waverly are really equivalent to the original Ohio formation, thus two of these are rendered doubtful, viz: *P. loganensis* and *P. peroccidens*. To these must be added four species referred to *Phillipsia*, *P. doris*, *P. insignis*, *P. meramacensis* and *P. rockfordensis* of which some may prove to belong to *Proetus*.

The list is then completed with *Brachymetopus* (?) *lodiensis* making ten species from the Waverly and its equivalents. To these we shall add seven additional species, all from the Waverly in Ohio and this by no means exhausts the known species, for several forms are too imperfectly represented for intelligible description. It must be noticed at the outset that the Waverly is not a homogeneous formation but a convenient term for a series of strata in Ohio which are more or less

similar lithologically, though including representatives of all the epochs from the Hamilton to the Chester or St. Louis. The evidence upon this question will be given at length in the sequel. Using the provisional divisions of the Waverly as suggested in our earlier discussion of this group we find the distribution of species in Ohio as follows; Upper division (carboniferous), *Phillipsia meramacensis*, *P. serraticaudata*, sp. n., *Phillipsia*, sp. n. (closely related with *P. auriculatus*), *Phaethonides occidentalis*, sp. n., and *Phaethonides immaturus*, sp. n.

In division II, or that consisting of the freestone of central Ohio and the adjacent shales, we have thus far but the single species, *Phillipsia auriculata* (= *Proetus missouriensis*) while in division I, embracing the lower and larger portion, we find *Phaethonides spinosus* sp. n., *Phillipsia* (?) *consors*, sp. n., *P. lodiensis*, Meek ? *Proetus præcursor*, Herrick, *Proetus minutus*, sp. n., and *Proetus* sp. ?, as well as near the top *P. auriculatus*. Thus in the lowest member the genera *Proetus* and *Phaethonides* predominate and the species referred to *Phillipsia* are at least closely related to *Proetus* and are of a Devonian rather than a carboniferous aspect. The middle division introduces no new element while the upper contains true *Phillipsias* as well as species of *Phaethonides* nearly allied to the carboniferous genus *Brachymetopus*. So far then as the distribution of the trilobites is concerned all facts sustain the conclusions elsewhere expressed as to the Devonian affinities of the faunæ of the two lower members. We add descriptions of the species.

GENERA PHILLIPSIA AND PROETUS.

While extreme examples of these genera as now understood are readily distinguished, they merge imperceptibly into each other, making the task of separating the allied forms very difficult. If one relies solely on the number of thoracic segments the resulting assemblages will be otherwise inconsistent not to mention the practical difficulty that, as the complete thorax is rarely preserved, we are forced in practice to depend on characters of pygidium and head. If it could be agreed to limit the genus *Proetus* to forms like *P. bohemicus*, Corda, the problem would be more simple. We append the diagnoses of the genera in parallel columns.

PHILLIPSIA.	PROETUS.
General form oval.	Do.
Head never over one-third the length and shorter than pygidium.	Head shorter than one-third and shorter than pygidium.
Head surrounded by raised border.	Do.
Glabella with parallel sides.	Do.
Basal lobes separated by a distinct furrow from rest of glabella.	Do. but smaller and more transverse.
Glabella with two or three furrows.	Glabella with three more or less distinct furrows.
Free cheeks produced into spines.	Free cheeks triangular less, frequently with spines.
Cervical suture deep, cervical segment high.	Do.
Eye large, faceted.	Do.
Thoracic segments nine (or ten.)	Thoracic segments eight to ten.
Pygidium with a rounded border which is usually narrow.	Border of pygidium rather broad and flat.
Number of segments large (from 10-18.)	Number of segments less (4-13).

PHILLIPSIA SERRATICAUDATA, sp. n.

(Plate I, Fig. 8, a—d.)

Glabella a little longer than wide, apparently about one-third as wide as entire shield, moderately elevated, surface rather depressed, narrower anteriorly, marked by three distinct lateral sulci with some indications of a fourth; postero-lateral (basal) lobes rather small, very oblique; produced back of the median lobe; the second and third furrows short, near together but separated by a wider interval from the first and less oblique. The elevated median lobe is separated by the very narrow anterior border by a narrow deep sulcus; neck segment very broad. Only a part of the movable cheek has been seen and it cannot be determined whether it is mucronate or not.

Outline of pygidium parabolic, length about two-thirds the width; median lobe rather convex, composed of about twelve segments which are separated by rather deep rounded grooves; lateral lobes moderate-

ly convex, marked by the same number of annuli as the median one, which are continuous to the very narrowed abrupt border. Segments ornamented along the posterior margin of the elevated portion by short, sharp, curved spines. This species is remarkable also for the distance of the convex, rather prominent termination of the median lobe from the free margin.

Length of glabella, 10 mm., width, 7.5 mm., distance from third lateral furrow to front 4.5 mm. Length of pygidium, 9 mm., width, 10 to 11 mm.

Seventy-five to one hundred feet above congl. II, Newark, 100 feet above congl. II, Rushville, and 108 feet above congl. II, in Richland Co. The horizon from which this species comes is well marked and restricted.

PHILLIPSIA (?) CONSORS, sp. n.

(Plate I, Fig. 16, a, b, c.)

Closely related apparently with *P. serraticaudata*, Her. Glabella almost exactly as in that species, length to width, as 8.5 to 5.5 at basal lobes; narrowed in front, depressed, marked by three lateral grooves, surface very densely marked by pustules of two sizes. From the species quoted the glabella differs in being rather longer proportionally, and more densely marked. The anterior part of head was not seen but very likely the border is narrow. Pygidium strongly elevated, parabolic, with a very narrow, smooth border; median lobe reaching rather nearer the posterior of pygidium than in *P. serraticaudatus*, composed of from 9 to 12 segments which are narrow, separated by concave grooves and ornamented by numerous perpendicular (not curved) pustules; lateral lobes strongly curved with about nine obvious segments ornamented as above.

Length of median lobe of glabella, 8.5 mm., width, 5.5 mm., length of pygidium, 9 mm., width, 10 mm. When flattened the pygidium approaches in proportions those of *P. serraticaudata*.

Five specimens were obtained at Lodi while looking for *P. lodiensis*, but there can be no possibility of our specimens belonging to that form. The structure of the head a little suggests *P. præcursor*, above the horizon of which it lies.

PHILLIPSIA MERAMACENSIS, Shumard.

(Plate I, Fig. 6.)

Our knowledge of this species rests on the single pygidium from an isolated exposure on a horizon about seventy feet below the Chester and apparently 110 to 120 feet above congl. II. It is undoubtedly near the horizon of *P. serraticaudata*. In as much as *P. meramacensis* was described from strata referred to the Chester, the close stratigraphical relation to acknowledged Chester rocks in Ohio is suggestive of an inference suggested by other facts, i. e., that the supposed hiatus above the Waverly does not in reality exist or at least is not as great as supposed. The Chester at this place is but about twenty-five feet thick and is followed without unconformity by sandy shales and a micaceous sandstone introducing the coal-measures. For description see Bul. Den. Univ. vol. iii, p. 28, and Plate XI of the same volume but published with Vol. IV.

PHILLIPSIA (PROETUS) AURICULATUS, Hall

(Plate I, Fig. 14.)

Proetus missouriensis, SHUMARD.*Phillipsia shumardi*, HERRICK.

For as complete a description as now possible see Bul. Den. Univ. vol. ii, p. 69.

The range of this species is for the most part limited to the free-stone of middle Waverly, but a specimen has been found immediately below conglomerate I and a variety not at present specifically separable occurs up to one hundred feet above conglomerate II. See opening sentences of present article for history of the species.

PHILLIPSIA (PROETUS) PRÆCURSOR, Herrick.

(Plate I, Fig. 1.)

This is a beautiful and characteristic species and seems quite rigorously limited to a zone scarcely 30 feet thick about seventy-five feet below conglomerate I. Specimens have been found only in one locality four miles west of Granville, where, however, the species is abundant.

Our *P. præcursor* differs from *P. haldemani* in having the genal angles produced. It is much like *P. microcephalus* but has a shorter glabella and smaller basal lobes.

In connection with this genus it is necessary to notice the only exception to the statement that no species of *Phillipsia* is known below the Waverly. *P. longicaudata*, H. described as from the Hamilton though some doubt was expressed whether it was not after all a coal-measure species, is certainly a *Phillipsia* and, judging from the figure, identical even in the state of preservation with *P. sangamonensis*, M. and W. It seems quite likely that the same specimen was employed in both figures, though it was derived from an unknown locality north-east of Des Moines, Iowa.

The genus *Phillipsia* proper, begins at the beginning of Division III, i. e., at that horizon which most nearly corresponds with the lower part of the Burlington group, and forms the introductory member of the Carboniferous in Ohio.

GENUS PROETUS.

The Devonian of America is well supplied with species of this genus, of which five species are found in the upper Helderberg. The corniferous limestone contains '*P. follicepts*, *P. clarus*, *P. canaliculatus*, *P. verneuili*, *P. microgemma*, *P. (?) planimarginatus*, *P. stenopyge*, *P. ovifrons*, *P. delphinulus* and *P. tumidus*—ten species. In the Hamilton Prof. Hall notes, *P. haldemani*, *P. macrocephalus*, *P. rowi*, *P. jejunus*, *P. phocion*, *P. prouti*, *P. nevadæ*, *P. occidentis*.

Then, strangely enough, the race seems to end. So far as evidence thus far has offered, trilobites ceased to exist with the end of the Hamilton, as no remains are known from the Portage and Chemung strata. This has naturally given much trouble to geologists in view of the considerable development of these crustacea in the Carboniferous. The whole difficulty disappears when the view here advocated is accepted and we find in Ohio a continuous sequence from Hamilton to Coal-measures with no serious break. The Hamilton genera are very gradually superceeded in the lower Waverly and the transition to the coal-measure species is complete.

PROETUS (?) (cf. HALDEMANI, H.)

(Plate I, Fig. 12)

Our material is too poor to permit a rigid definition of the species, but its position is so near the base of the Waverly that its peculiarities may warrant a reference.

Head unknown; thorax consisting of nine slightly convex segments, the axial and pleural portion having about the same width, length slightly over twice the width; pygidium over one-half as long as broad, very flat, consisting of about ten coalesced segments, axial lobe very wide, considerably over one-third the entire width, terminating obtusely near the margin; pleural surface gently convex with about nine obvious segments which are low and separated by shallow grooves. There are some indications that there may have been a broad plane border, in which case the proportions would correspond to *P. shumardi* quite nearly. It is quite unlikely that it is identical with that species, however.

One mile east of Harlam, Licking Co., in shale 200–300 feet from the base of the Waverly.

PROETUS MINUTUS, sp. n.

(Plate I, Fig. 7, a, b.)

An exceedingly small species quite unlike its associates.

General form broadly oval, head as long as the pygidium; glabella large with very small, strongly marked basal lobes and elevated median lobe, which is narrow, with parallel sides and terminates at some distance from the front margin. The markings are not displayed, the surface being exfoliated. Cervical suture deep, cervical segment apparently narrow. Median lobe of glabella nearly twice as long as broad. Thorax with nine segments, very distinctly trilobed. Pygidium two-thirds as long as broad, with a very wide concave border, axial segments eleven or twelve, pleural segments eleven. Pygidium rather flat with rounded costæ which disappear toward the margin.

Moot's run, Licking Co., O.

GENUS PHAETHONIDES, Angelin, 1878.

The present writer had gone so far as to separate the species now to be described with *Phillipsia lodiensis*, Meek, as constituting a separate genus allied to *Brachymetopus* when the adoption and modification by Prof. Hall of the genus *Phaethonides* fell under his notice. Hall, however, does not entirely agree with its founder in the application of the name to the group for which Barrande proposed *Phaethon*.

This name was applied to proetoid forms with fimbriated pygidium. As amended by Angelm, this genus includes both forms of pygidia where the glabella is short and ovoid, having distinct basal lobes and two pairs of faint obsolescent, lateral furrows in front of the lobes. As stated by Hall the genus connects *Cyphaspis* and *Proetus* and (as he might have said) introduces *Brachymetopus*.

Diagnosis. Cephalon as in *Cyphaspis* [semicircular, genal angles produced into spines. Glabella strongly arched, short and narrow, with two small pyriform basal lobes, bounded on all sides by deeply impressed furrows. Anterior lateral furrows obsolete] the frontal area, however, being more deeply concave and the lateral glabellar furrows stronger and generally duplicate. Thorax composed of not less than seven narrow segments and probably more. Axis wide. Pygidium Proetoid, relatively large, bearing from eight to twelve annulations upon the axis and eight or nine upon the pluræ. These annulations extend to the margin and are conspicuously duplicate their entire length. Surface turberclered or smooth." The genus extends from the Upper Helderberg to the Hamilton, and, as we now show, to the close of the Chemung in Ohio.*

PHAETHONIDES OCCIDENTALIS, sp. n.

(Plate I, Fig. 10, a, b.)

Glabella two-thirds as long as the head-shield not including the neck segment, sub-oval, quite tumid behind but flattened anteriorly, highest point rather behind the middle, distinctly separated by a groove from the small lateral lobes, also marked near the anterior third by a slight depression at the sides; head-shield in front of the glabella gradually descending to the rather narrow somewhat elevated border which is set off by a broad ill-defined groove; eyes apparently distant from the glabella, cervical segment narrow, separated from the glabella by a narrow deep groove, entire surface tuberculate. (The specimen does not preserve the entire shield, but it was evidently much more broadly rounded than is usual in *Brachymetopus*.)

Pygidium semi-elliptical, elevated, consisting of about sixteen

*In the Trans. of N. Y. Acad. Sci., June 4th 1888, Mr. Vogdes describes from the Waverly of Sedalia, Mo., *Griffithides ? sedaliensis*, Vogd, which seems to belong to the present group.

united segments, axis rather more than one-third the entire proximal width, tapering gradually to its blunt prominent distal extremity, which is near the margin, strongly elevated and ornamented by a series of tubercles on each of the segments, which are circular in section and separated by deep, narrow grooves; pleural portions suddenly and strongly deflected at a short distance from the axial lobe, but becoming less oblique to form the narrow margins which are not otherwise defined, the nine or ten pleural ribs are elevated and keeled, the keel bearing from two to five small tubercles and extending out upon the free margin as a strong rib, terminating in a tooth or tubercle on the free margin; length of pygidium four-fifths or more of the width. Length of pygidium, 8 mm., width, 10 mm. Length of head-shield, 7 mm., length of glabella, 4.4 mm.

Several heads and pygidia were collected in conglomerate II at Granville and Newark.

PHAETHONIDES SPINOSUS, *sp. n.*

(Plate I, Figs. 4-5.)

Glabella two-thirds as long as head including the neck-segment, narrow, not much expanded posteriorly, form much as in *P. occidentalis*, but with smaller postero-lateral lobes and no indication of an anterior pair of grooves. Anterior margin of head narrow, separated from the median lobe of glabella by a very shallow concavity which becomes convex as it nears the glabella. Surface profusely set with high tubercles, those upon the glabella forming about eight rows, lateral lobes with three small spines.

Pygidium of large size for the genus, very convex and much arched, composed of fourteen coalesced segments, axial lobe elevated, its segments moderately convex, separated by comparatively shallow and not very narrow grooves, and ornamented by five sharp almost spinous tubercles, of which the central one is largest and separated from the lateral ones by a greater interval than separates the latter; pleural surfaces convex, suddenly depressed near the middle of their width nearly perpendicularly to the shallow groove separating the very narrow margin; eight or nine pleural ribs carinate, with from one to four spinous tubercles, ribs nearly disappearing in the marginal groove but springing into an oblique acute spine on the raised margin. The ribs of the pleura bifurcate near the margin by the division of that por-

tion of the ribs behind the keel. Length of head, 6 mm., length of glabella, 4 mm., width, 3 mm. Length of pygidium, 7 mm., width, 9-10 mm.

This beautiful species is found at Moot's run 70 to 80 feet below congl. I. The pygidium is very like that of *P. occidentalis* but the greater coarseness of the ribs and the spinous armature with minor features serve to distinguish the species, which differ more widely in the characters of the head.

Calcareous concretions seventy feet below conglomerate I, Licking and Ashland counties.

PHAETHONIDES? IMMATURUS, sp. n.

(Plate I, Figs. 9 and 15.)

This species is known only from pygidia, none of which preserve the characters perfectly. It is quite possibly this is the species described by Meek as *Phillipsia lodiensis* but in as much as it is not found on the same horizon it seems better to distinguish it.

Pygidium rather flat in all specimens seen, semi-elliptical, axial portion with about twelve lobes, rather rapidly tapering, pleura with duplicate ribs anteriorly, about eight being visible, extending out upon the rather narrow but obvious margin where they are slightly nodose, median and lateral lobes ornamented by about three large distant tubercles. This is a very small species occurring 100 feet above conglomerate II, at Newark and also in the upper layers at Cuyahoga Falls. Fig. 9 is from the latter place and considerably enlarged by camera. It has been called *P. lodiensis* by collectors.

PHAETHONIDES (?) LODIENSIS, Meek.

(Geol. Surv. O. vol. ii. Palaeon. Plate XVIII.)

The figures of this species make it probable that it is congeneric with *P. spinosus* and it is apparently but little above it stratigraphically. Collectors seem to have confused with it our *P. immaturus* or other species from a higher horizon. The form of glabella with the long median lobe ally it with some forms of *Proetus*.

CYTHERE OHIOENSIS, sp. n.

(Plate VIII, Fig. 8, Vol. III. Plate III, Fig. 19.)

Carapace narrowly ovate, smooth; profile rhomboidal, acute at either end; valves marked by a rather acute prominence near the middle of the length and one-third from the dorsal margin, surface very strongly arched toward the dorsal margin, more gently inclined to the ventral margin.

Length, 7 mm., width, 35 mm. Common in the upper part of division III, at Newark, Rushville and Ashland Co.

The generic reference is purely provisional, the species resembles a *Leperditia* in some respects, though seeming like an enlarged *Cytherella*. It may be compared with a form figured by Meek from Nebraska.

Before taking up the general discussion of the list here presented we should study the Coelenterata, Echinodermata, Bryozoa, and Pisces, of all which groups more or fewer specimens have been secured. Unfortunately the material collected in all but one is very meager, while the crinoids have already been quite fully discussed by Prof. Hall. The Bryozoa are abundant upon several horizons. We have been so fortunate as to secure the assistance in this difficult group of the highest authority upon the subject of sub-carboniferous Bryozoa, Mr. E. O. Ulrich, whose work in connection with the Geological surveys of Minnesota and Illinois places him in a position to speak authoritatively upon this group. This is of special moment in the present instance in as much as the localities furnishing Bryozoa (excepting a single horizon) are well up in the series and have been referred on other grounds by us to just those epochs chiefly represented in Illinois,

Of the kindness of Mr. Ulrich in preparing and donating the following paper we desire to make special acknowledgment.

Prof. C. L. Herrick, Denison University, Granville, Ohio.

DEAR SIR :—

I transmit herewith a brief report on Waverly bryozoa. Had I been less pressed for time it would without doubt have been more full and more reliable. Still, I hope you will find it suited to your purpose.

By combining the fine lot of material you sent me for study with my own I believe I have been enabled to present a fair idea of the bryozoan fauna of this much-discussed series of strata. That which strikes one as not only interesting but important in the questions at issue relating to the equivalence of the various beds comprised within the term Waverly group is the fact that no remains of this class of fossils have as yet been obtained from strata below the top of the Berea shales. So far as I have been able to ascertain there is a complete absence of bryozoa in all the divisions between the top of the Erie and the base of the Cuyahoga shales.

In looking over the 41 species that have been determined, I find that no less than 17, or over 41 per cent. of the entire number, occur in the Burlington and Keokuk beds of Iowa, Illinois and Kentucky. Not a single species indicates an horizon above the base of the St. Louis limestone. Of these, 3 species occur in the Burlington and 16 in the Keokuk, while 2 of the Burlington species also occur in the Keokuk.

The bryozoa are thus decidedly indicative of an equivalence between the Cuyahoga shales on the one hand and the Keokuk group on the other.

Many of the species identified and others mentioned in drawing comparisons between nearly related forms are described in Vol. VIII, Illinois Geological Survey report. To prevent repetition the names of these species are usually distinguished by an asterisk.

Respectfully Yours,

E. O. ULRICH.

A LIST OF THE BRYOZOA OF THE WAVERLY GROUP
IN OHIO. WITH DESCRIPTIONS OF NEW SPECIES.

By E. O. ULRICH.

FENESTELLA HERRICKANA, n. sp.

(Plate XIII, Fig 2—2d.)

Zoarium of moderate extent, apparently flabellate and more or less undulating.

Obverse.—Branches comparatively rigid and rather slender, eight or nine in 5 mm., 3.5 mm., to 4.0 mm. wide, increasing very gradually to 4.5 or 5.0 mm. before bifurcation takes place; margins somewhat wavy; surface between the zooecia apertures depressed and marked with from one to three (usually two) short striations. *Carina* usually distinct but only moderately developed, not sharp, swelling or forming tubercles at intervals corresponding nearly to the zooecia mouths, occasionally nearly obsolete, in which case the nodes are more conspicuous than usual. Zooecia in two ranges, thirteen or fourteen in each in 5 mm., apertures four or five opposite a fenestrule, circular, 0.2 mm. in diameter, surrounded by well developed peristome which (in the perfect state) is ornamented by a circle of small tubercles. The space between succeeding orifices about equals the diameter of a peristome. Opercular coverings slightly convex, with a small central elevation. *Dissepiments* thin, depressed, faintly striated, rounded or sub-angular. *Fenestrules* narrow, the length two to four times greater than the width; seven or eight in 10 mm. longitudinally.

Reverse.—Here the branches are strongly rounded and striated longitudinally. On old example the striæ become nearly or quite obsolete and the whole surface finely granulose. The granules are of two sizes, the larger ones being much less abundant and inclined to arrange themselves in rows.

This beautiful species may be compared with the *F. cingulata** from the Keokuk group of Illinois, which likewise has a row of minute granules upon the peristomes of the zooecia. That species however, has a more compact and robust aspect, stronger dissepiments and shorter fenestrules. *F. compressa*,* from the same horizon in Kentucky has a much higher keel, and differs in other aspects.

Formation and locality:—Not uncommon at Moot's Run, Licking Co., O. Rare at Richfield, Ohio.

FENESTELLA MEEKANA, n. sp.

(Plate XIII, Fig. 1—1b.)

Zoarium of lax growth, probably flabellate, spreading nearly in a plane and, so far as known, not exceeding 50 mm. in height.

Obverse:—Branches rather strong and straight, seven or eight in 10 mm., with an average width of .05 mm., increasing from about 0.45 mm. immediately after bifurcation to about 0.60 mm., before the next division takes place. Bifurcation recurring at intervals, varying between 6.0 mm. and 11.0 mm. *Carina* obsolete; median region of branches with two to four rather unequal and irregularly flexuous striæ, and an occasional node. Spaces between zooecia apertures usually with two or three short striæ. *Zooecia* in two ranges, ten in each in 5 mm.; usually six or seven opposite each fenestrule, but, the length of the latter being variable, it sometimes happens that eight or even nine may be observed. *Apertures circular*, 0.12 mm., in diameter, separated two and one-half times that distance, with the margin thick and elevated but not ring-like. *Opercula* occasionally preserved, slightly convex and radially marked around the small central perforation or boss. *Dissepiments* striated, depressed, less than half the width of the branches, but expanding at their junction with them. *Fenestrules* large, varying from 0.7 to 1.2 mm. in width and 2.2 to 4.5 mm. in length, averaging, however, about three in 10 mm.

Reverse:—On this side the branches and dissepiments are rounded and marked by granulose striæ, four or more on each branch.

In Vol. II Pal. of Ohio, Meek describes from about the same horizon at Lodi, a form which he separates as a variety of *F. multi-*

*This mark appended to a species signifies that it is one of those described by me in the forthcoming Vol. VIII of the Reports of the Illinois Geological Survey.

porata, McCoy. After a careful study of his figures and description it seems evident to me that he included more than one species under his variety. I am not certain that the form here named in his honor is not one of them, while the *F. albida*, Hall, and its variety *richfieldensis* of the present paper most likely served in describing the reverse. The specimen from which he prepared his figure of the celluliferous side being apparently in a good state of preservation must have been different from these, since it shows neither a carina nor striæ between the ranges of zooecia. If the figure correctly represents his specimen I should consider it as clearly distinct from the form here called *F. meekana*. On comparing the figures of the last species with Meek's, other differences may be noted, i. e., the zooecia apertures in the latter are more closely arranged, and the fenestrules smaller.

F. meekana is readily distinguished from all Devonian and Carboniferous species of the genus known to me by the large fenestrules. In the absence of a keel the species approaches to the two and three named *Polypora*.

Formation and locality:—Richfield. A small fragment that may belong to this species occurs on a slab from Lodi, Ohio.

FENESTELLA ALBIDA, Hall.

(Plate XIII, Fig. 3—3c.)

Fenestella albida, HALL. Sixth Ann. Rept. State Geol. N. Y., 1887, p. 48.

Plate VII, Fig. 1-7.

Zoarium large, probably flabelliform, spreading in a plane, or very slightly undulating toward the outer extremity of large fragments. The largest fragment seen is 120 mm. long, and about 50 mm. wide.

Obverse:—Branches very slender, nearly straight, fifteen or sixteen in 10 mm., mostly about 0.35 mm. wide; about 0.25 mm. wide just after, and 0.40 to 0.50 mm. wide just before bifurcating. The branches are sometimes nearly parallel and always diverge rather slowly, the bifurcations occurring at intervals of usually more than 35 mm. and rarely less than 20 mm. *Carina* thin, slightly elevated, with about four small nodes in 5 mm. *Zooecia* in two ranges, sixteen or seventeen in each in 5 mm.,† the two ranges strongly interlocking in the interior. Apertures circular, nearly direct, more than their diam-

†Hall says (loc. cit.) 20, but his figure shows only sixteen in 5 mm.

eter apart, surrounded by a thin peristome, five to eight, usually six or seven, opposite each fenestrule. Longitudinal space between apertures often faintly striated. Dissepiments very slender, depressed, sub-angular. Fenestrules wider than the branches (occasionally two or three times), the length equal to two or three times the width; six in 10 mm.

On the *reverse* the branches are strongly rounded and, as usual, striated longitudinally.

Formation and locality:—The typical form of this species is not very abundant at Richfield, O., where it is associated with the much more common variety next noticed.

FENESTELLA ALBIDA var. **RICHFIELDENSI**S, n. var.

(Plate XIII, Fig. 3-3c.)

This variety or species differs from the typical form of *F. albida* mainly in the peculiarly irregular and lax growth of its fronds. They are also always smaller and not unfrequently much folded while in many the expansion is of palmate shape. The largest example seen (nearly complete) is 60 mm. long and nearly the same in width. The branches are also less straight and the fenestrules more variable in size and shape. In some of the specimens a few branches are stronger than the rest, and the whole may assume an irregular pinnate arrangement. Figure 3 represents a portion of such a specimen. On the *reverse*, also, the branches are usually narrowly rounded or sub-angular, a feature not noticed on typical examples of the species.

This variety brings the species into close proximity with *F. filistrata*,* Ulrich a Burlington limestone species. That species, however, is less delicate, has the median keel or carina blunt, and the whole surface finely striated.

Formation and locality:—Very abundant at Richfield O., associated with numerous species of crinoidea.

FENESTELLA APERTA, Hall.

Fenestella aperta, HALL, 1887. Sixth Ann. Rept. State Geol. p. 58, pl. IV, figs. 1-5.

Zoarium consisting of very delicate expansions. The largest seen is over 50 mm. long and less than 20 mm. wide. Another fragment is 35 mm. long and 30 mm. wide.

Obverse.—Branches twenty-two or twenty-three in 10 mm., very slender, nearly straight, diverging with moderate rapidity, the bifurcations occurring at intervals varying between 5 mm. and 15 mm.; average width about 0.33 mm., just above a bifurcation about 0.25 mm. increasing to about 0.40 mm. at the next division. *Carina* thin, inconspicuous, often sinuous, generally nodose, the nodes nearly as numerous as the zooecia apertures. *Zooecia* in two ranges, eighteen or nineteen in each in 5 mm.; apertures sub-circular, a little oblique, their diameter apart, with a distinct though thin peristome projecting slightly so as to indent the border of the fenestrules; three or four opposite each fenestrule. *Dissepiments* very slender, about half as wide as the branches, depressed, sub-angular, occasionally channeled, scarcely expanding at their ends. *Fenestrules* oblong-quadrangular, the length equalling about twice the width, between ten and eleven in 10 mm.†

On the *reverse*, the branches and dissepiments are rounded and either faintly striated or nearly smooth.

This delicate species is readily distinguished from the *F. albida*, Hall, with which it is usually associated by its thinner branches, finer and more regular net work, and the fenestrules being much smaller. The species is related to *F. compressa*, Ulrich,* from shales of the Keokuk group at King's Mountain, Ky. What may prove to be identical form occurs in the "Division beds" at the top of the Burlington limestone. The specimens so far seen, however, are too illy preserved to admit of a satisfactory determination of this point.

Formation and locality :—Upper Waverly,* (Cuyahoga shale) at Richfield, O.

FENESTELLA FOLIATA n. sp.

(Plate XIII, Fig. 4.)

Zoarium a small, sub-circular, flabellate or leaf-shaped expansion, not known to exceed 17 mm. in height by 15 mm. in width.

Obverse.—Branches slender, diverging rapidly, more or less flexuous, particularly near the base, eight or nine in 5 mm., with an av-

†Hall's measurements relating to the dissepiments and fenestrules differ widely from what is shown in his figures. He says, "about five in the space of 10 mm.," but figures 1, 2 and 3 agree with the specimens before me in showing ten or eleven in that space.

erage width not 0.38 mm.; bifurcation frequent, the intervals varying between 1 mm. and 4 mm. *Carina* thin, moderately elevated, faintly nodose, the nodes distant from each other about 0.5 mm. *Zooecia* in two ranges, eighteen in each in 5 mm.; apertures circular, 0.11 mm. in diameter, directed a little obliquely upward and outward, with well developed peristome drawn out posteriorly into an oblique ridge, and projecting laterally so as to indent the border of the fenestrule. *Dissepiments* depressed, thin, finely striated, expanding very little at their junction with the branches. Fenestrules irregular in shape and size, with from seven to nine in 10 mm.

On the *reverse* the branches and dissepiments strongly rounded, and covered with short striations, or minute granules. The fenestrules here are wider than on the other side of the zoarium.

This neat species is related to *F. albida* var. *richfieldensis* and *F. filistriata*, Ulrich,* from the Burlington limestone of Iowa. From the former it differs in the smaller zoarium, more flexuous branches, narrower and smaller fenestrules, and more closely arranged zooecia apertures. The *reverse* side of the branches is also differently marked. These differences also apply when compared with the Burlington species, that form being further distinguished by its finely striated obverse.

Formation and locality :—Cuyahoga Valley below second fall.

FENESTELLA SUBFLEXUOSA, n. sp.

(Plate XIII, Fig. 6.)

Zoarium a small leaf-shaped expansion, 20 mm. long and 16 or 18 mm. wide.

Obverse:—Branches slender, laterally compressed, between 0.3 mm. and 0.4 mm. wide, diverging rapidly, irregularly flexuous, seven or eight in 5 mm.; bifurcations frequent, so far as observed, the intervals vary between 1.5 mm. and 6 mm. *Carina* thin, strongly elevated, carrying small but rather prominent nodes 0.2 to 0.3 mm. apart. *Zooecia* in two ranges, seventeen or eighteen in 5 mm.; apertures circular, small, about 0.08 mm. in diameter, nearly direct, surrounded by well developed peristome, a little more than their diameter apart. *Dissepiments* very thin, sharply angular, only a little depressed, not expanding at their junction with the branches. *Fenestrules* of irregular form and unequal sizes, unusually eight in 10 mm.

On the *reverse* the branches are striated longitudinally and rounded.

This form is closely allied to both *F. foliata* and *F. albida* and I am not prepared to hold that more abundant material than has come under my notice will not prove it to be specifically identical with one of them. The characters relied upon in distinguishing it are the more flexuous compressed branches, less depressed dissepiments, the greater prominence of the carina, and the absence of striæ in the longitudinal spaces between the zooecia apertures.

Formation and locality:—Cuyahoga shales, thirty feet below Carboniferous conglomerate at Cuyahoga Falls.

FENESTELLA CAVERNOSA, n. sp.

(Plate XIII, Figs. 7-7b.)

Zoarium strongly folded, probably infundibuliform. All the specimens are fragmentary, the largest about 50 mm. long and 40 mm. wide.

Obverse.—Branches nearly straight, of moderate strength, rather unequal, averaging 0.41 mm. in width.; immediately after bifurcating the width is about 0.3 mm., and just beneath the next division about 0.5 mm., the rate of increase between the two extremes being gradual. The bifurcation occurs at intervals varying between 6.0 mm. and 15.0 mm., and not unfrequently take place simultaneously in a number of neighboring branches, causing a considerable variation in the number of branches in a given space. Thus while the average number in 10 mm. is seventeen or eighteen, as few as sixteen and as many as twenty-two may occur in an equal space, on certain portions of a frond. *Carina* small, often slightly sinuous, generally with faint nodes or swellings at rather irregular intervals. Entire surface between zooecia apertures minutely porous, the pores elongate so that they not infrequently cause the surface to appear finely striated. *Zooecia* in two ranges, fourteen or fifteen in 5 mm.; apertures nearly direct, circular, 0.09 mm. in diameter, a greater distance apart, three, occasionally four, opposite each fenestrule, and surrounded by a well developed peristome, sometimes obliquely prolonged posteriorly. In the thinner branches the peristomes project slightly beyond the margin of the branches. *Dissepiments* somewhat depressed, half as wide as the branches, expanding at each end. *Fenestrules* twice as long as wide,

or a little wider than the branches, nine, sometimes ten in 10 mm.

Reverse.—Here the branches are more or less strongly rounded, the dissepiments nearly on a plane with them, and both somewhat thinner, the fenestrules larger than on the opposite face of the zoarium. The whole surface is covered with the sub-angular or elongated orifices of small pores, usually exhibiting a marked tendency to a longitudinal arrangement.

This peculiar species is known only from natural moulds of the exterior, and the characters above described are furnished by gutta-percha impressions. Those showing the obverse side exhibit a feature as yet not well understood, but which I am inclined to attribute to a peculiar state of preservation. The mouths of most of the zooecia are surrounded, namely, by a circular impression instead of a raised margin. This feature appears so anomalous that in preparing figure 7-a I have taken the liberty to substitute (excepting in the upper right hand zooecium) a raised line where the gutta-percha shows an impressed one. If I am right in ascribing this anomalous character to an unusual state of preservation then it is not impossible that the porous condition of the branches and dissepiments is due to the same cause. This, however, is not probable, yet, if true, they must represent structures of some kind—tubercles perhaps.

In its measurements this species approaches closely to *F. Herrickana*. Aside from the supposed differences in the surface markings they differ in the following particulars: *F. Herrickana* has thirteen or fourteen zooecia in 5 mm and seven or eight fenestrules in 10 mm. where *F. cavernosa* has, respectively, fourteen or fifteen and nine or ten.

Formation and locality:—Waverly group, at Sciotoville, Ohio, where it occurs, associated with *Streblotrypa amplexus* and numerous brachiopoda in ferruginous clay nodules.

FENESTELLA REGALIS, Ulrich.

(Plate XIII, Fig. 5, 5a.)

Fenestella regalis, ULRICH. Rept. Ill. Geol. Surv. Vol. VIII, pl. 1, fig. 1, 1a. (now in press.)

All of the Ohio specimens of this species before me are mere fragments. The most of them agree quite closely with the typical

Kentucky examples. Several however, are more delicate and have sixteen instead of fourteen zooecia in the space of 5 mm. The apertures also are a little larger and the peristomes very little developed. The fragment here figured is one of them and shows these features very well. If a name is desirable they may be styled *Fenestella regalis* var. *macer*.

Formation and locality: The types are from shales of the Keokuk group at King's Mountain, Ky., while the Ohio specimens come from the Cuyahoga shale at Richfield and Lodi.

FENESTELLA BURLINGTONENSIS, Ulrich

Fenestella burlingtonensis, ULRICH. Rept. Ill. Geol. Surv. pl. XLIX, fig. 1, 1a. (now in press.)

Several worn fragments of a species apparently identical with the Burlington types of this species occur on a small slab from Lodi, O. Associated with them are more or less weathered examples of no less than ten distinct species of Bryozöa, among them *F. regalis*, *Ptilopora paupera*, *Pinnatopora Vinei*, and *Rhombopora incrassata*, all described by me from the Keokuk group of Kentucky and Illinois in the delayed vol. VIII, Illinois Geological Survey.

FENESTELLA TENAX, Ulrich.

Fenestella tenax, ULRICH. Ill. Geol. Surv. vol. VIII, pl. II, figs. 2-2d. (in press.)

Two years ago I received several fragments of fossiliferous rock from Rev. H. Herzer which he had collected in the upper beds of the Waverly series at some locality in Cuyahoga Co. These furnished good gutta-percha impressions of both the *obverse* and *reverse* sides of a small species of *Fenestella* that I cannot now distinguish from the Kentucky and Illinois types of *F. tenax*. This species though probably the most abundant in the Chester limestone, began its existence as early as the formation of the Keokuk group, a number of specimens collected at Keokuk, Iowa, and Nauvoo, Illinois, being, apparently, identical with the Warsaw and Chester examples, as well as with the Ohio specimens now before me.

UNDETERMINED SPECIES OF FENESTELLA.

Among Prof. Herrick's material there are two specimens of a

small flabellate species, forming a rather closely woven network. The species is probably new, but as both show only the *reverse* and, as the characters of the more important opposite could not be ascertained, it is not described. The specimens are from the Cuyahoga shales about thirty feet below the Carboniferous conglomerate, at Cuyahoga Falls.

Another specimen from a layer of ferruginous freestone at Bagdad shows only the *obverse* and that not in a satisfactory manner. As near as can be determined it belongs to a species either very closely related to or identical with *F. multispinosa*,* Ulrich, a Keokuk species occurring in Kentucky, Iowa and Illinois. It also agrees rather closely with Meek's description of his *F. delicata*, described from nearly the same horizon at Lodi.

Several other species of this genus known to me from the Ohio Waverly series are too imperfect for satisfactory comparisons.

POLYPORA IMPRESSA, n. sp.

(Plate XIII, Figs. 8, 8a.)

Zoarium small, flabellate. *Branches* comparatively slender, between 0.4 mm. and 0.62 mm. wide, about four in 1 mm.; bifurcations frequent, occurring at intervals of from 1 mm. to 5 mm., the intervals being shortest near the base. *Zooecia* mainly in two ranges, but where the distance between the bifurcations is more than 3 mm., a third range is interpolated. *Apertures* small, strongly elevated, with the margin denticulate when perfect. Over at least the upper half of the zoarium there is a large, oval, rather shallow, yet more or less sharply margined impression behind most of the apertures. Near the base of the frond these impressions are either very indistinct or quite obsolete, and the zooecia apertures rise from the surface of the branch very much as in certain species of *Stomatopora* and other *Cyclostomata*.

In the branches with only two ranges of zooecia the apertures are situated along the border of the branch and frequently project a little over it. About fourteen zooecia in each range in the space of 5 mm. *Dissepiments* slender, slightly depressed, finely striated, generally less than half as wide as the branches. *Fenestrules* elongate, varying in shape and size, from 1.5 mm. to 3.0 mm. long, the width equalling generally about half their length and one and a half or two times the width of the branches.

On the *reverse* the branches and dissepiments are evenly rounded and faintly striated.

In the frequent bifurcations of the branches, widely separated dissepiments and general aspect of the zoarium, this species approaches *Thamniscus*, King, and I am inclined to believe that when this group of species, to which *P. gracilis*, Prout, also belongs, is better understood, they will be removed from *Polypora*. In my Illinois work on the bryozoa I have already placed several species of this type with *Thamniscus*, having been able to show that *T. dubius*, Schlotheim, the type of the genus, also, (at least occasionally) has some of the branches united by dissepiments. Much study and an abundance of material is required before a final disposal of these peculiar species is possible.

Taking all its characters into consideration, *P. impressa* is not likely to be confounded with any other species known to me. Similar impressions behind the zooecia apertures are present in the Upper Carboniferous *Thamniscus octonarius*, Ul.* This character is one of rare occurrence among palæozoic bryozoa and brings some of the mesozoic and recent forms to mind.

Formation and locality :—Cuyahoga shale of the Waverly series, between 50 and 100 feet below the Carboniferous conglomerate, at Richfield, Summit Co., Ohio. The type specimen is attached to the surface of a small fragment of a ferruginous clay nodule, less than two inches square. With it are more or less fragmentary remains of at least seven other species of bryozoa.

POLYORA GRACILIS, Prout.

Polypora gracilis, PROUT, 1860. Trans. St. Louis Acad. Sci. vol. I, p. 580.

" " PROUT, 1866, Geol. Surv. Ill. vol. II, p. 422, pl. XXI, figs. 1, 1a.

" " ULRICH, Ibid. vol. VIII, pl. LXXI, figs. 10, 10a (Now in press.)

Two specimens, one from Richfield, the other from Sciotoville, are provisionally referred to this species. The first shows only the reverse, while the second is an illy preserved mould of the obverse. There is, therefore, no certainty that they belong to *P. gracilis*, especially since there are several distinct species of this type in the Burlington and Keokuk limestones.

POLYPORA RADIALIS, Ulrich.

Polypora radialis, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LX, figs. 1, 1d.

Natural moulds in freestone of this small infundibuliform species are abundant in the upper 30 feet of the Waverly series near Newark, Ohio, while a single example was collected by the author in the Cuyahoga shales at Richfield where it was associated with numerous species of crinoids, *Fenestella albida*, *F. aperta*, and species of *Pinnatopora*. There seems no reason to doubt the specific identity of the Ohio specimens with the Illinois and Iowa types. At those more western localities the species is known only from shales of the Keokuk group.

PTILOPORA PAUPERA, Ulrich.

Ptilopora paupera, ULRICH. Ill. Geol. Surv. vol VIII, pl. LXVI, fig. 10.

A fragment of this species occurs on a small slab filled with bryozoan remains of numerous species. Among them I recognize the following: *Fenestella burlingtonensis*, *F. regalis*, *Pinnatopora Vinei*, *Rhombopora incrassata* and *R. confuens*. All of these species are described by me in volume VIII of the Illinois Geo. Surv. reports, now in press, the first from the Burlington limestone, the remainder from shales of the Keokuk group in Kentucky and Illinois. The types of *P. paupera* are also from Keokuk shales. This interesting slab is one of several collected by Prof. Herrick at Lodi, O.

PINNATOPORA INTERMEDIA, n. sp.

(Plate XIV, Fig. 1.)

Zoarium pinnated. The only specimen seen consists of four primary branches each 2 cms. or more long, that evidently belonged to one zoarium. All present the reverse side to view.

Midrib slender, about 0.3 mm. wide, slightly flexuous, with the reverse rounded and striated longitudinally. On the obverse side the two ranges of zooecia apertures are separated by a thin sharp carina, carrying rather distant small nodes. Lateral branches or pinnæ from 1 to 3 mm. long, half as wide as the midrib, often united to each other by very slender non-celluliferous dissepiments, forming an angle of about 50 degrees with the midrib, and numbering ten or eleven on each side in 10 mm. Primary portions of zooecia in two alternating ranges

in the midrib; in the lateral branches they are wedge-shaped and form a single series only. Apertures small, circular, in two ranges, one situated at the base of each lateral branch and two or three between. As near as can be determined, there are about twenty on each side of the midrib in 5 mm

In having the longer lateral branches united by dissepiments this species approaches *Ptilopora*, but the general aspect and growth of the zoarium is so much like *Pinnatopora* that it has seemed advisable to place the species as above rather than under the former genus. If, however, possession of non-celluliferous dissepiments is insisted upon as being the only point of difference between the two groups, then the species will have to stand as *Ptilopora intermedia*. In any event the specific name will indicate the intermediate character of the form.

Compared with other species *P. intermedia* will be found to differ from *Ptilopora valida*, Ulrich,* from an equivalent horizon in Illinois, in being much more delicate, and from the associated *Pinnatopora tenuiramosa*, Ulrich,* in having the lateral branches less numerous in a given space and directed much more toward the distal extremity of the zoarium. In the last species the pinnæ form an angle of nearly 80° with the midrib.

Formation and locality :—Cuyahoga shales of the Waverly series, at Richfield, O.

PINNATOPORA SIMULATRIX, n. sp.

(Plate XIV, Fig. 3.)

Zoarium pinnate, the reverse only seen. Midrib comparatively strong, about 0.6 mm. wide, somewhat flattened or broadly rounded and very finely striated longitudinally. Lateral branches (pinnæ) depressed, slender, about 0.2 mm. wide, 1 to 2 mm. long, with fifteen given off on each side in 10 mm.; they form an angle of about 70° with the midrib and the longer ones are occasionally united to each other by exceedingly thin dissepiments.

This is another species that simulates *Ptilopora* in having some of the longer lateral branches united by dissepiments. I am, however, inclined to hold that species of the type of this and the preceding ones cannot be removed from *Pinnatopora* if we propose to make natural affinity the primary desideratum of our classifications. *P. simulatrix*

is closely related to *P. intermedia* but differs in having the reverse more finely striated and more numerous lateral branches in a given space. *P. intermedia* has them more oblique and less numerous.

Formation and locality:—Same as the preceeding.

PINNATOPORA CURVATA, n. sp.

(Plate XIV, Fig. 4.)

Zoarium pinnate, reverse aspect only observed. Midrib straight, about 0.4 mm. wide, rounded and finely striated. Pinnæ about eight on each side in 10 mm., unusually oblique, forming an angle of 45° with the midrib; they are from 1 to 2 mm. long, curved and about half as wide as the midrib.

So far as observed, this species differs from *P. striata*, Ulrich,* from the Keokuk group of Iowa, in the curved and more oblique pinnæ. Of the latter also there are eight where that species has seven. *P. flexuosa*, Ulrich,* from the same horizon in Kentucky has the lateral branches separated by even longer intervals. There are five or six in 10 mm. *P. intermedia* is a more delicate species and has ten or eleven lateral branches in 10 mm.

Formation and locality:—Same as the preceeding.

PINNATOPORA SUBANGULATA, n. sp.

(Plate XIV, Fig. 2.)

Zoarium pinnate. Midrib nearly straight, between 0.3 mm. and 0.4 mm. wide, with the reverse side more or less angular and marked by from three to five longitudinal striæ of which the central one is the strongest. Pinnæ straight, between 1 and 2 mm. long, about half as wide as the midribs, with usually twelve, sometimes eleven or thirteen in 10 mm.; they form an angle of from 65° to 70° with the midrib, and on the reverse side are finely striated. On old examples the striæ on both midribs and pinnæ bear rows of minute granules. Zooecia in two ranges, about nineteen on each side of the midribs in 5 mm., with one opposite each lateral branch and two in the space between. Apertures circular, surrounded by a distinct peristome, their diameter or less apart. Intermediate spaces very finely granulo-striate. Carina moderately developed, rather rounded than sharp, with nodular swellings at intervals corresponding nearly to the length of a zooecium.

The sub-angular character of the reverse distinguishes this species from all others known to me. In other respects it resembles *P. tenuiramosa* very closely. *P. Vinei* also is a nearly related species but, aside from the different form and markings of the reverse, is distinguished by the smaller number of pinnæ and zooecia in a given space.

Formation and locality:—Cuyahoga shales of the Waverly series, about 30 feet below the Carboniferous conglomerate at Cuyahoga Falls.

PINNATOPORA MINOR, n. sp.

(Plate XIV, Fig. 7, 7a.)

Zoarium very small, pinnate. Midrib about 0.32 mm. wide, throwing off the pinnæ sub-alternately from the two sides, at an angle of nearly 80°. The latter are short, less than 1 mm. long, about 0.19 mm. wide, and eight or nine on each side in 5 mm. Reverse side of midrib broadly rounded or somewhat flattened along the middle, and marked by three fine longitudinal striæ, bordered on each side by a smooth space. Obverse face ridge-shaped, the carina comparatively strong and bearing inconspicuous nodes at intervals a little longer than a zooecium. Zooecia in two ranges, with subcircular or elliptical apertures, about 0.09 mm. in diameter, with moderately developed peristome, much the highest on the outer side. The apertures are arranged one at the base of each lateral branch and one in the intermediate space, with about sixteen on each side of the midrib in 5 mm.

This neat species resembles *P. Youngi*, Ulrich,* in nearly every respect excepting size, that being one of the most robust forms of the genus while this is one of the smallest. Its diminutive fronds are easily distinguished from the associated species.

Formation and locality:—Upper beds of the Cuyahoga shales, at Richfield, O.

PINNATOPORA VINEI, Ulrich.

(Plate XVI, Fig. 5.)

Pinnatopora Vinei, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LXVI, figs. 5, 5b. (In press)

I cannot see that the Ohio specimens of this species differ in any essential respect from the Kentucky and Illinois types. Being one of

the most abundant of the bryozoa so far found in Waverly series, a description is desirable in this place. I take the liberty, therefore, of appending my description of the species as it will appear in the work above cited.

"Zoarium pinnate; midrib slender, usually straight, 0.4 to 0.45 mm. wide, with the reverse side evenly rounded and finely striated. Obverse face low ridge-shaped, the mesial carina rounded, not prominent, with rather strong nodes at irregular intervals. Lateral branches from 1 to 2 mm. in length, like the midrib but only two-thirds as wide, opposite or sub-alternately given off from the sides of the midrib; nine or ten in one cm. Zooecial apertures in two alternating ranges, fifteen in 5 mm., subcircular, with faintly elevated thin peristome, about 0.1 mm. in diameter. All the interspaces between the apertures very finely striated longitudinally."

Some of the Ohio specimens have the midrib as wide as 0.5 mm.

The thinner midrib, larger lateral branches, and shorter zooecia distinguish this species from *P. Youngi*.

Formation and locality:—The original types are from the Keokuk group at King's Mountain, Ky. During the last year I have also found it in beds of the same age at Keokuk, Iowa. The Ohio specimens come from the Cuyahoga shales at Richfield, Lodi and Bagdad, Ohio.

PINNATOPORA YOUNGI, Ulrich.

(Plate IV, Figs. 6, 6a.)

Pinnatopora youngi, ULRICH. Geol. Surv. Ill. vol. VIII, pl. LXVI, fig. 3. (In press.)

The following description is copied from my MS. for the work above cited.

"Zoarium pinnate, comparatively strong. Midrib strong, averaging 0.6 mm. wide, with the reverse side broadly convex and finely striated. Obverse side somewhat flattened, with a strong, rounded, mesial keel, bearing large but not prominent nodes at intervals of about 0.8 mm. Entire obverse face between the zooecial apertures very finely striated. Lateral branches short, at their origin about three-fourths as wide as the midrib, tapering rapidly toward their rounded distal extremity; opposite or alternating, with eleven on each side in 1 cm., given off at an angle of from 60° to 80°. Zooecia in alternating ranges. Apertures subcircular, with a very thin and slight-

ly elevated peristome, about 0.1 mm. in diameter, and 0.3 mm. apart; eleven in 5 mm. They are arranged so that one is opposite a lateral branch and one between."

"This species though closely allied to several English and Scotch species is nevertheless quite distinct. Of American forms, *P. Vinei* seems to be closer than any other, but differs in being smaller and in having three zoecia where this has two."

The Ohio specimens present more variation in the strength of the midribs than the original Kentucky and Iowa examples. While the average is about as given above, in some the width is only 0.5 mm., and in others nearly 0.8 mm.

Formation and locality :—The Ohio examples are from the Cuyahoga shales at Richfield and Lodi. The types are from the Keokuk group at King's Mountain, Kentucky, and Keokuk, Iowa.

PINNATOPORA TENUIRAMOSA, Ulrich.

Pinnatopora tenuiramosa, ULRICH, Ill. Geol. Surv. vol VIII, pl. LXVI, fig. 7. (In press.)

My remarks on this species in the above work read as follows: "Of this species only the reverse aspect has been observed. The best fragment seen preserves a portion of the primary branch about 1 cm. long. This is between 0.6 or 0.7 mm. wide, and on one side throws off three, on the other only one secondary branch, varying in width from 0.5 to 0.6 mm. The primary and secondary lateral branches or pinnæ, diverge at angles of from 70 to 80°, are slender, about one-third as wide as the principal branches, from less than 1.0 to nearly 3.0 mm. long, those proceeding from the primary branch the longest, with twelve or thirteen given off on each side in the space of 1 cm. Surface of both branches and pinnæ marked with fine distinct longitudinal striæ."

Since the above was written I have collected a good suite of specimens at the original locality. Like the type specimens none of these show the obverse face in a satisfactory manner. As near as can be determined, that aspect must resemble that of *P. Vinei* very closely, and it is not impossible that better specimens of both species than I have yet seen may show the propriety of uniting them under one name. All the specimens that I have referred to *P. tenuiramosa* have twelve or thirteen pinnæ on each side in 10 mm. Those referred to *P. Vinei* are equally constant in having nine or ten in the same space. *P. sim-*

ulatrix. another closely related form has fifteen lateral branches in 10 mm. and the larger ones sometimes united by a dissepiment.

Formation and locality :—Cuyahoga shales of the Waverly series at Richfield, O.

TÆNIODICTYA INTERPOLATA, n. sp.

(Plate XIII, Figs. 9, 9a.)

Zoarium bifoliate, ramose; dividing dichotomously or otherwise at frequent but unequal intervals, the extremes noticed being 4 mm. and 15 mm. Branches acutely elliptical in transverse section, 2.5 to 3.0 mm. wide, and about 0.5 mm. thick. Margins sharp, narrow, granulo-striate. Zooecia arranged in diagonally intersecting curved lines and in more or less regular longitudinal series, those near the border a little larger than those in the central region of a branch. The longitudinal arrangement is more pronounced in some examples than in others. Apertures elliptical, sometimes nearly circular, comparatively large, averaging 0.25 mm. long by 0.18 mm. wide. When the arrangement is regular the ends of the apertures are separated by either one transversely elongated pit or mesopore or by two small ones. On some examples or portions of their surface the pits are more numerous and somewhat irregularly distributed. The interspaces or walls between the zooecia apertures and mesopores are comparatively thin and obtusely ridge-shaped. Measuring longitudinally about fourteen zooecia occur in 5 mm.; diagonally ten or eleven in 3 mm.

The minute internal structure of the walls is very much like that of *T. ramulosa*, the type of the genus.

The intermediate pits that distinguish this species from the three forms upon which I established the new genus *Taeniodictya* in my forthcoming Illinois work lends this species a resemblance to *Stictoporella*. That genus, however, is essentially a Lower Silurian group and, though I place Lower Carboniferous forms under it, I am strongly inclined to question the propriety of the arrangement. Until an exhaustive study of the palæozoic bifoliate bryozoa is made the arrangement of species under the various genera must be regarded as tentative, and as the form under consideration presents no very marked deviation from the typical species of the proposed genus *Taeniodictia*, the wisest course for the present seems the one here adopted.

Formation and locality :—Cuyahoga shales. This species was

first brought to my notice several years ago by Rev. H. Herzer of Cleveland, O. Since then I have collected it myself at Richfield, O. Rev. Herzer's were collected by him at localities in Cuyahoga Co.

CYSTODICTYA ZIGZAG, n. sp.

(Plate XIII, Fig. 11, 11a.)

Zoarium bifoliate, ramose, consisting of a main branch either nearly straight or more or less zigzag, from 1.3 mm. to 2.3 mm. wide, which throws off sub-alternately from the sides somewhat narrower branches. The latter may remain simple or become divided in a manner similar to the main branch. The lateral branches, if they may be so called, are given off at intervals of about 4 mm., so that about three occur on each side of a main branch in 20 mm. Zooecia in six to eight rows on the main branches and in six or seven on the lateral ones; apertures widely separated, small, subelliptical, with a moderately developed peristome, highest on the outer or lunar side; as a rule they are not regularly arranged but sometimes curved diagonal and longitudinal rows may be determined with distinctness. Usually about ten occur in 5 mm. longitudinally and between six and seven in 3 mm. diagonally. Interspaces rather wide; in young or macerated specimens exhibiting sinuous striæ; in old examples either smooth or covered with exceedingly minute granules.

This species is distinguished from others of the genus by the peculiar growth, it being the only one known to me branching in the manner above described.

Formation and locality:—Cuyahoga shales of the Waverly series at Richfield O.; also in the Keokuk group at Keokuk, Iowa.

CYSTODICTYA SIMULANS, n. sp.

(Plate XIII, Fig. 10.)

Zoarium bifoliate, ramose, branching dichotomously at intervals of 8 mm. more or less. Branches acutely elliptical in cross section, from 2.8 mm. to 4.0 mm. wide, margined on each side with a narrow non-celluliferous strip. Zooecia apertures rather large, subcircular, with a strongly elevated and rather thick peristome when fully matured. The apertures are often arranged in more or less curved transverse rows, which may extend completely across the width of a branch

or terminate near the middle. Where this arrangement prevails the peristomes of neighboring apertures coalesce and form what may be termed beaded ridges. In these transverse rows five apertures occur in 2 mm. and from six to eight suffice to cross the branch; measuring longitudinally, eight or nine rows occur in 5 mm. In other examples, an arrangement in fairly regular longitudinal and diagonally intersecting series is evident. In these, nine apertures occur in 5 mm. lengthwise, and six in 5 mm. diagonally. In all the diameter of the apertures situated near the borders is a little greater than that of those near the center of a branch. Sub-centrally perforated opercular covers close many of the zooecia orifices on the specimen illustrated on Plate XIII. Interspaces smooth or very finely granulo-striate.

The position of this species is intermediate between *C. ocellata*, Ulrich, and the Coal Measure species *C. carbonaria*, Meek.

Formation and locality :—Waverly group at Moot's Run, Licking Co., Ohio, about 200 feet below the top of the series. Also in the Keokuk group at Warsaw, Ill., and Keokuk, Iowa.

CYSTODICTYA ANGUSTA, sp. n.

Plate XIV, Fig. 20.

Of this species I have seen only small fragments of which the largest is figured. None of them show any indication of having been branched. The basal portion is preserved on one of them. This grew around some slender foreign object, is comparatively large, and exhibits irregularly distributed apertures of a number of zooecia. From one side there arises a free branch like the fragment illustrated. The latter presents the following characters: It is between 0.8 and 0.9 mm. wide, 0.5 mm. thick, sub-elliptical in cross section, curved, with the margins narrowly rounded and granulo-striate. The surface presented to view has two rows of zooecia apertures, with twelve in each row in 5 mm. By removing a portion from the matrix it has been ascertained that the opposite side bears three rows. The zooecia apertures are subcircular, rather large, about 0.18 mm. in diameter and surrounded by slightly elevated thick peristomes. The surface between the rows of apertures is rounded or sub-angular and presents several interrupted sinuous striae or series of granules. The longitudinal spaces between the zooecia apertures is transversed by one

or two oblique granulose striæ. Sub-centrally perforated opercular covers close many of the orifices.

This interesting species can scarcely be confounded with any other known to me. Its narrow branches and only two and three rows of comparatively large subcircular zooecia apertures distinguish it from *C. americana*, Ulrich,* *C. parallela*, Phillips, in which the zooecia form from three to six rows and have narrower apertures arranged between rounded ridges.

Formation and locality :—Waverly group at Moot's Run, Licking Co., Ohio. Collection of Prof. Herrick.

CYSTODICTYA, sp. undet.

Among the material sent me for examination by Prof. Herrick there are a number of beautifully preserved fragments of a species of *Cystodictya* collected by him in Moot's Run, a very interesting locality in Licking Co. As I do not intend to name the form I might have left them without remark were it not for the fact that the same variety also occurs in the Keokuk group of Illinois. In arranging my collections from those western localities I placed the form as a variety of my *C. lineata*, and that may be its true position. Still, both the Ohio and Illinois examples of the variety are easily distinguished from the typical specimens of that species in wanting the prominent rounded longitudinal ridges that suggested the name *lineata*. The variety differs further in having more nearly circular, though still oval, and larger zooecia apertures and more distinct peristomes. The lunarium also is not so strongly developed. On the whole, therefore, I believe that when this difficult group of bryozoa has undergone the careful revision now but fairly begun by me, characters will be found to distinguish at least three or four species among the material now classed as varieties of *C. lineata*.

GLYPTOPORA MEGASTOMA, Ulrich.

Glyptopora megastoma, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LXXVIII, figs. 5, 5a (In press.)

Two specimens from Sciotoville, where they were found associated with *Spirifera striatiformis*, Meek, *Streblotrypa amplexa*, Ulrich,

and *Fenestella cavernosa*, Ulrich, are referred to this species. The types are from the Keokuk group of Illinois and Iowa. In the collection of E. O. Ulrich.

STREBLOTRYPA MAJOR,† Ulrich.

(Plate XIV, Fig 10.)

Streblotrypa major, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LXXI, figs. 8, 8d, and pl. LXXII, figs. 1, 1a.

The following description of this species is copied from my MS. for the above work: "Zoarium a comparatively robust, dichotomously or otherwise divided stem. Often found flattened from pressure. The divisions of the branches occur at long intervals and are often unequal. Zooecia apertures oval, 0.25 mm. long and about 0.15 mm. wide, surrounded by a narrow sloping area, only noticeable in perfect specimens; arranged in longitudinal series (interrupted at more or less frequent intervals) between subangular longitudinal ridges, that are not distinct from the aperture margin but form their lateral boundaries. The longitudinal interspaces between the succeeding zooecia apertures exhibit the mouths of from one to three short ranges of mesopores. These pores vary considerably in size, and in number from three to twelve, but when the zooecial arrangement is regular, their number is generally either four or six. Measuring longitudinally, about ten zooecia apertures occur in 5 mm."

"Of internal characters, the comparative shortness of the zooecial tubes, the non-development of an inferior hemiseptum, and the rather irregular appearance of the tubes in the axial region, are the most noteworthy."

"The large zooecia and rather robust zoarium easily distinguished this species from all others of the genus known to me."

†The genus *Streblotrypa* was proposed in MS. by me several years ago, and specimens of the type species, *S. Nicklesi*, (Ill. Geol. Surv. vol. VIII), were sent to students of palæozoic bryozoa. The name was adopted for a supposed variety of the type species by Mr. G. R. Vine, in 1886. (Notes on the Joredale Polyzoa of North Lancashire). During November or December, 1887, there appeared vol. VI of the Palæontology of N. Y. In looking over this fine work I find that Prof. Hall has placed at least one species under his new genus *Acanthoclema* that ought rather to be regarded as a form of *Streblotrypa*. The species referred to is the *Ceriopora hamiltonensis* of Nicholson. The typical species of *Acanthoclema* are quite different, being, like his sub-division *Orthopora*, closely related to *Rhombopora*.

The Ohio examples of this species are somewhat smaller than the Kentucky types, but there can be no question of their specific identity.

Formation and locality:—Keokuk group at King's Mountain, Ky., and Keokuk, Iowa. The Ohio examples are from the Cuyahoga shales at Richfield, O. Collection of E. O. Ulrich.

STREBLOTRYPA OBLIQUA, n. sp.

(Plate XIV, Fig. 9.)

This species or variety of *S. major* is represented by but a single example which has suffered somewhat through compression. It consists of a nearly straight stem about 2.5 mm in diameter, and 25 mm. long, widening at the upper extremity where it is broken, as though a bifurcation was about to take place. The zooecia apertures open obliquely, are large, oval, 0.20 mm. long by 0.13 mm. wide, and, though a little more crowded and irregular, are arranged much as in *S. major*. In the rather irregular longitudinal series nine or ten zooecia occur in 5 mm.; measuring diagonally eight or nine in 3 mm. The apertures of the zooecia are situated at the bottom of sloping areas, with the slope gentle and widest above, giving them the appearance of being drawn out trough-like. At posterior margin there is a slightly elevated thin lip. The top of the areas of adjoining zooecia unite to form irregular and more or less sharply angular longitudinal ridges. The mesopores are rather irregularly arranged though mainly situated between the ends of the zooecia apertures. They number two, three or four to each zooecium.

This form is closely allied to *S. major* and may represent only a variety of that species. The only specimen seen however, appears so different in its thicker interspaces, oblique zooecia apertures and less abundant mesopores that another designation seems necessary.

Formation and locality:—Cuyahoga shales of the Waverly series at Lodi, O. Collection of Prof. C. L. Herrick.

STREBLOTRYPA HERTZERI, n. sp.

(Plate XIV, Fig. 8.)

Zoarium consisting of remotely bifurcating stems, about 2 mm. in diameter. Zooecia apertures direct, oval or subcircular, large, rather

unequal, 0.25 to 0.38 mm. in length, arranged in not very regular diagonally intersecting and longitudinal series, nine in 3 mm. diagonally and ten in 5 mm. longitudinally. Sloping area very narrow. Walls thin, mesopores irregularly distributed, sometimes forming small clusters of ten or more, around which the zooecia are often larger than usual. Normally from two to six mesopores occupy a variously shaped space back of each zooecium, so that the latter is in contact with four other zooecia. Internal structure not observed.

This species is nearly related to *S. major*, Ulrich, but the thinner walls and the absence of longitudinal ridges serve to distinguish it. *S. obliqua* has much thicker walls and oblique zooecia apertures; *S. amplexa* more abundant mesopores and smaller zooecia.

Rev. H. Herzer of Cleveland, O., was the first to bring this species to my notice, and I take the opportunity of naming it for him as a slight token of my appreciation of the uniform kindness and generosity which he has always extended to me.

Formation and locality:—Cuyahoga shales of the Waverly series at Richfield, Lodi and several localities in Cuyahoga Co., Ohio. Very rarely also in the Keokuk group at Keokuk, Iowa. Collection of E. O. Ulrich.

STREBLOTRYPA AMPLEXA, n. sp.

(Plate XIV, Fig. 13.)

Zoarium consisting of remotely bifurcating stems, 1.7 mm. to 1.9 mm. in diameter. Bifurcations 20 mm. or more apart. Zooecia apertures direct, broad oval, of moderate size, 0.15 to 0.22 mm. in their larger diameter, arranged in rather regular diagonally intersecting series, with six in 2 mm.; measuring longitudinally ten or eleven occur in 5 mm. Sloping area and walls of moderate thickness. Mesopores abundant, completely isolating the zooecia; averaging six or seven to each zooecium.

Internal structure unknown.

This species stands intermediate between *S. Hertzeri* and *S. multiporata*. From the former it differs in having smaller zooecia apertures and more abundant mesopores, from the latter in having the zooecia larger and the mesopores less numerous.

Formation and locality: Waverly group. The natural moulds of this fine species were quite abundant near Sciotoville, O.

STREBLOTRYPA MULTIPORATA, n. sp.

(Plate XIV, Fig. 11.)

Zoarium ramose, the stems somewhat irregularly cylindrical, about 1.7 mm. in diameter. Zooecia apertures direct, subcircular, of unequal sizes, 0.08 to 0.15 mm. in diameter, irregularly arranged, sometimes scarcely distinguishable from the mesopores. Mesopores very abundant, completely isolating the zooecia, often arranged in interrupted longitudinal series. Two or three of these rows are generally arranged between short ridges. Walls and sloping areas of moderate thickness.

The smaller zooecia and exceedingly numerous mesopores distinguish this species from *S. amplexa*, its nearest congener.

Formation and locality:—Waverly group. Moot's Run, Licking Co. Ohio.

Prof. C. L. Herrick's collection.

STREBLOTRYPA STRIATA, n. sp.

(Plate XIV, Figs. 12, 12a.)

Of this species I have four fragments varying from 6 to 15 mm. in length and 0.5 to 0.9 mm. in diameter. None of them are branched. The surface is traversed by strong parallel longitudinal ridges which may continue in a nearly straight line for a considerable distance. At other times they are frequently interrupted, and sometimes assume slightly oblique or sinuous directions. Between these ridges which carry prominent nodes at irregular distances apart, the zooecia apertures are arranged. The latter are oval, about mm. long and mm. wide, and surrounded by a well developed peristome. The concave space between succeeding apertures and the principal ridges is usually occupied by one or two finer striæ. About† occur in 5 mm. measuring longitudinally.

On old examples it is difficult to make out the zooecia, the peristomes being less distinct than in younger specimens, and the whole surface appears finely striated longitudinally.

This very neat and distinct species may be compared with *S. multiporata* and *S. (?) denticulata*. Its stems are more slender than those

†It was discovered too late for correction that these measurements had been omitted in the MS. C. L. H.

of the former and the numerous mesopores are not represented. The absence of denticles around the apertures suffice to separate it from the latter.

Formation and locality:—Cuyahoga shales of the Waverly series. Three of the specimens come from near Richfield. The fourth from an unknown locality in Cuyahoga Co., O.

STREBLOTRYPA REGULARIS, n. sp.

(Plate XIV, Fig. 14.)

Zoarium ramose, branches very slender, about 0.5 mm. in diameter. Zooecia apertures ovate, 0.15 mm. long, 0.1 mm. wide, appearing to open somewhat obliquely, arranged regularly in alternating longitudinal series and rapidly ascending diagonal rows, with a small shallow pit at each end, the upper one generally merging into the aperture, the lower one separated by a slightly elevated margin forming the posterior border of the zooecia aperture. The most elevated portion of the surface is that between the two pits, being often prominent enough to appear like a spine. Measuring longitudinally, twelve zooecia occur in the space of 5 mm. About eleven rows in the circumference of a branch. Interspaces rather thin, narrowly rounded and plain. The pits are easily overlooked, particularly so on specimens partly obscured by adhering matrix. In these the zooecia apertures seem greatly elongated and their ends separated by a thin and prominent transverse wall, which clean examples show to be only the divisional ridge between the inter-apertural pits.

I know of no species sufficiently resembling this to require detailed comparisons.

Formation and locality:—Cuyahoga shales of the Waverly series at Burbank, O. Another example is from the same horizon at a locality in Cuyahoga Co.

Prof. C. L. Herrick and E. O. Ulrich's collection.

STREBLOTRYPA (? LEOCLEMA) DENTICULATA, n. sp.

(Plate XIV, Figs. 18, 19)

Zoarium irregularly ramose, branches cylindrical, 1 mm. to 1.3 mm. in diameter. Zooecia apertures rather small, suboval, 0.13 mm. in diameter, denticulate, being surrounded by an elevated margin or

peristome carrying from four to six comparatively strong tubercles; the latter are more or less regularly arranged and project slightly over the apertures. Between the apertures, which are widely separate, the surface is transversed either by irregularly interrupted and unequal longitudinal ridges or by nearly straight continuous ones between which the apertures are ranged in longitudinal series with about nine in 5 mm. When the more regular arrangement prevails the strong ridges may unite with the spiniferous peristomes or pass by them on or both sides, while the concave space between succeeding apertures exhibits one or two thinner and less elevated ridges which continue from one peristome to the next in either a straight or an oblique direction. The length of the spaces traversed by them equals between two and three times the diameter of the zooecia apertures.

This interesting and peculiar species cannot be confounded with any other form of *Streblotrypa* known to me. In fact, it is even possible (as indicated above) that it does not belong to this genus at all but rather to *Leioclema*, the denticulate apertures being very suggestive of the most typical species of that genus. Still, taking all the known characters into consideration, it does not now appear probable that this suggestive external feature will be borne out by an examination of the interior. I regret to say that the preservation of the specimens at hand did not permit me to apply this test.

Formation and locality:—Cuyahoga shales of the Waverly series, at Richfield, Lodi and several localities in Cuyahoga Co., O.

Collections of Prof. C. L. Herrick and E. O. Ulrich.

RHOMBOPORA INCRASSATA, Ulrich.

(Plate XIV, Fig. 16, and (?) 16a.)

Rhombopora incrassata, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LXX, figs. 12, 12a. (In press.)

The Ohio specimens of this species seem to agree in every particular with the typical examples coming from shales of the Keokuk group of Kentucky.

The original of fig. 16a is referred here with some doubt as it had more acanthopores (now represented by small pores) than I have ever seen on examples of the species. Were it not for the strong internal thickening, in which it greatly resembles *R. incrassata*, I would place it with the peculiar *R. spiralis*, Ulrich.* The originals of the last

species are not in a very good state of preservation and better specimens may prove that my figures of them are defective in not showing a sloping area and in having the zooecia apertures too large.

Formation and locality :—The Ohio specimens are from the Cuyahoga shales at Lodi; the types of both *R. incrassata* and *R. spiralis* are from the Keokuk group at King's Mountain, Ky.

Collection of Prof. C. L. Herrick.

RHOMBOPORA OHIOENSIS, n. sp.

(Plate XIV, Fig. 4.)

Compare *Rhombopora dichotoma*, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LXX, figs. 13, 13b.

Zoarium ramose, bifurcation distant. Branches cylindrical, between 1.0 and 1.3 mm. in diameter. Zooecia apertures arranged in longitudinal and diagonally intersecting series, oval, small in the old state, longer when young, the diameter becoming smaller with age by an internal deposit of sclerenchyma. Interspaces ridge-shaped, more acute in the young than in the fully matured state. The interspaces form sinuous ridges, alternately approaching and diverging from each other; rarely coalescing, usually leaving a narrow depression between the ends of the sloping areas that surround the zooecia apertures. Summit of ridges with a row of small tubercles (acanthopores?). measuring longitudinally ten or eleven zooecia occur in 5 mm.; diagonally seven in 2 mm. The diagonal rows intersect each other at an angle of about 65°.

The form briefly described above is so much like *R. dichotoma*, Ulrich, from the Burlington limestone of Iowa that I am strongly inclined to regard it as only a local variation of that species. The number of zooecia in a given space and the general aspect of the surface is the same, the only differences observed being the greater frequency of the narrow sulcus between the ends of the cells, the more acute angle at which the diagonal rows intersect each other and the smaller diameter of the branches.

A still smaller form, with more frequently bifurcating branches, 0.7 or 0.8 mm. in diameter, occurs at the Richfield, Lodi and Burbank exposures. Whether this should be separated from *R. Ohioensis* is as yet undetermined. It agrees very closely (so also does *R. Ohioensis*) with a common species of the Keokuk group of Iowa and Illi-

nois. More study than I can give them now is necessary before the inter-relations of these closely allied forms can be determined with anything even approaching satisfaction.

Formation and locality:—Cuyahoga shales of the Waverly series at Richfield, Lodi, Cuyahoga Co., and Moot's Run in Licking Co., Ohio. Those from the last locality are derived from strata occupying a lower horizon in the series.

Prof. C. L. Herrick's and E. O. Ulrich's collections.

RHOMBOPORA CONFLUENS, Ulrich.

(Plate XVI, Fig. 17.)

Rhombopora confluens, ULRICH, Geol. Surv. Ill. vol. VIII, pl. LXX, figs. 5, 5b. (In press.)

The Ohio specimens are larger and the small node below the aperture is usually absent, while the sinuous longitudinal ridges appear as though they had borne a row of minute granules, and coalesce more often than is the case in the type specimen of the species. None of these differences are of sufficient importance to cast doubt upon their specific identity.

Formation and locality:—The original examples come from the upper beds of the Keokuk group at Warsaw, Ill. The Ohio specimens from the Cuyahoga shales at Lodi.

Among the Richfield and Lodi material I can make out at least two species of *Rhombopora*. These, as they could not be illustrated, have not been studied very carefully. One of them seems closely related to a Burlington limestone species. (*R. gracilis*, Ulrich,*).

LEIOCLEMA PUNCTATUM.

Callopora punctata, HALL, 1888. Pal. Iowa, vol. I, pt. 2, p. 653.

Leioclema punctatum, ULRICH, 1882. Jour. Cin. Soc. Nat. Hist. vol. V, pl. VI, figs. 1, 1a.

Leioclema punctatum, ULRICH, 1882. Ill. Geol. Surv. vol. VIII. (In press.)

A mould of the exterior in freestone from the Cuyahoga valley below the second falls, represents, probably, this common Keokuk species. The gutta-percha casts agree exactly with slightly weathered examples of the species from many localities in Illinois and Iowa.

LEIOCLEMA GRACILLIMUM, Ulrich.

Leioclema minutum, ULRICH. Ill. Geol. Surv. vol. VIII, pl. LXXV, fig. 6, 6a.
(In press.)

A small fragment attached to a slab from Lodi differs in no appreciable respect from the Illinois and Iowa examples upon which this species is founded. At those more western localities the species ranges from the Burlington limestone upwards to the top of the Keokuk group.

FISTULIPORA, sp. undet.

Three species of this genus are known to me from the Waverly group of Ohio. None of them have been sufficiently examined to determine their relations. One, from the Sciotoville beds, is a ramose species like *F. compressa*, Rominger, but not identical with it. Another, from the same horizon and locality, is parasitic. The third, from Richfield, O., a small discoid species with rather large, oval zooecia is attached to the frond of *Polypora impressa* figured on Plate XIII.

STENOPORA, sp. undet

A fragment of a ramose species of this genus closely related to *S. montipora*, Ulrich,* from the Keokuk group of Iowa, was found by me near Richfield, O., in the Cuyahoga shale about twenty feet below the conglomerate.

PLATE XIII.

- Fig. 1.** *Fenestella Meekana*, n. sp.-----p. 64.
 1. A specimen of the natural size from Richfield, O. Coll. of E. O. U.
 1a. Portion of obverse of same x 9
 1b. One branch of same x 18, showing striations and opercular covers in three of the zooecia apertures.
- Fig. 2.** *Fenestella Herrickana*, n. sp.-----p. 63.
 2. A fragment of this species of the natural size. Coll. of C. L. H.
 2a. Obverse side of same x 9.
 2b. One branch of 2a x 18, to show more clearly the ornamentation and opercular covers.
 2c. Reverse of same x 9, showing the longitudinally striated condition.
 2d. A branch of another specimen x 18, showing the reverse side in the old condition where the striæ have become obsolete and the whole surface covered with minute granules.
- Fig. 3.** *Fenestella albida*, HALL.-----p. 65.
 3. A specimen of the natural size belonging to the variety of *Richfieldensis*. The irregular growth often seen in the variety is unusually striking in this specimen. Coll. of C. L. H.
 3a. Portion of same x 9, showing the subcarinate character of the reverse.
 3b. Small portion of the obverse face of another specimen x 9.
 3c. A branch of 3b x 18, to show the characters more clearly.
- Fig. 4.** *Fenestella foliata*, n. sp.-----p. 67.
 4. A nearly complete zoarium of this species of the natural size. Coll. of Prof. C. L. H.
 4a. Portion of a specimen showing obverse face x 9.
 4b. A branch of 4a x 18.
 4c. Several branches from near the base of fig. 4 x 9, showing reverse side.
- Fig. 5.** *Fenestella regalis*, ULRICH.-----p. 70.
 5. A small fragment of this species x 9, having thinner branches and larger cell apertures than usual.
 5a. A branch of same x 18 to show the surface markings more clearly.
- Fig. 6.** *Fenestella subflexuosa*, n. sp.-----p. 68.
 6. Obverse of a gutta-percha cast of this species x 9, showing the widely separated zooecia apertures, but little depressed dissepiments and finely nodose carina. Coll. of Prof. C. L. H.
- Fig. 7.** *Fenestella cavernosa*, n. sp.-----p. 69.
 7. A fragment of the natural size. Coll. of E. O. U.
 7a. A branch showing the obverse side x 18.
 7b. Portion of the reverse of another example x 9, showing the porous character of this face of the zoarium.

- Fig. 8. *Polypora impressa*, n. sp.-----p. 72.
 8. A nearly entire zoarium of the natural size. A small species of *Fistulipora* is attached to it. Coll. of E. O. U.
 8a. One branch of same x 18, showing the strongly elevated denticulate mouths of the zooecia and the large depression beneath each.
- Fig. 9. *Taniodictya interpolata*, n. sp.-----p. 80.
 9. A gutta-percha cast of a mould in ferruginous freestone, natural size. Coll. of E. O. U.
 9a. Surface of another specimen x 18, showing the form and arrangement of the zooecia and intermediate pits.
- Fig. 10. *Cystodictya simulans*, n. sp.-----p. 81.
 10. A specimen of the natural size, showing the arrangement of the zooecia. Coll. of Prof. C. L. H.
- Fig. 11. *Cystodictya zigzag*, n. sp.-----p. 81.
 11 and 11a. Two fronds of this species, natural size, showing variations in the mode of branching and in the width of the branches.

PLATE XIV.

- Fig. 1. *Pinnatopora intermedia*, n. sp.-----p. 74.
 1. A specimen of natural size, showing the reverse and a portion x 9, showing the dissepiments and, where the zoarium has been removed, a mould of the opposite face. Coll. of E. O. U.
- Fig. 2. *Pinnatopora subangulata*, n. sp.-----p. 76.
 2. A specimen of natural size, showing the reverse and a portion x 9, showing the subcarinate characters of this face of the zoarium. Coll. of Prof. C. L. H.
- Fig. 3. *Pinnatopora simulatrix*, n. sp. p.-----75.
 3. A specimen of natural size, showing the reverse and a portion x 9. The latter shows the somewhat flattened character of the midrib and on one side pinnæ connected by slender dissepiments. Coll. of E. O. U.
- Fig. 4. *Pinnatopora curvata*, n. sp.-----p. 76.
 4. A specimen of natural size, and a portion of same x 9. The figure shows the strong upper direction and slightly curved form of the pinnæ. Coll. of E. O. U.
- Fig. 5. *Pinnatopora Vinci*, ULRICH.-----p. 77.
 5. A specimen x 9, showing the character of the obverse face on the upper half and of the reverse face in the lower half. Coll. E. O. U.
- Fig. 6. *Pinnatopora youngi*, ULRICH.-----p. 78.
 6. A specimen x 9, showing the obverse side. Coll. E. O. U.
 6a. An unusually strong specimen of the natural size. Coll. of Prof. C. L. H.

- Fig. 7. *Pinnatopora minor*, n. sp.-----p. 77.
 7. A fragment of the natural size and its obverse side x 9.
 7a. A fragment showing the characters of reverse, natural size and x 9. Coll. E. O. U.
- Fig. 8. *Streblotrypa Hertzeri*, n. sp.-----p. 85.
 8. A fragment of the natural size with a portion of the surface x 18, showing the arrangement of the large zooecia and mesopores. Coll. E. O. U.
- Fig. 9. *Streblotrypa obliqua*, n. sp.-----p. 85.
 A branch of this species with a portion of its surface x 18, showing the thick walled zooecia, their oblique apertures and the arrangement of the mesopores. Coll. Prof. C. L. H.
- Fig. 10. *Streblotrypa najor*, ULRICH.-----p. 84.
 10. A fragment of a small specimen of this species, natural size and a portion x 18. Coll. of E. O. U.
- Fig. 11. *Streblotrypa multiporata*, n. sp.-----p. 87.
 11. A branched fragment of the natural size and a portion of the surface of same x 18, showing the small zooecia apertures and very numerous mesopores. Coll. of Prof. C. L. H.
- Fig. 12. *Streblotrypa striata*, n. sp.-----p. 87.
 12. The lower portion of a fragment of this species x 18, showing the appearance of the surface when the arrangement of the zooecia and ridges is regular.
 12a. The upper end of same fragment x 18, exhibiting a somewhat less regular arrangement of the ridges. Coll. of E. O. U.
- Fig. 13. *Streblotrypa amplexa*, n. sp.-----p. 86.
 13. Portion of a fine ramose example of this species with a portion of the surface x 18 to show the arrangement and comparative size of the zooecia and mesopores. Coll. of E. O. U.
- Fig. 14. *Streblotrypa regularis*, n. sp.-----p. 88.
 14. Fragment of this species of the natural size and x 18, showing the shallow pits and other peculiarities of the species. Coll. of Prof. C. L. H.
- Fig. 15. *Rhombopora ohioensis*, n. sp.-----p. 90.
 15. A specimen from the ferruginous freestone layers of the Cuyahoga shales showing the appearance of the surface in the young state x 18.
 15a. A branched fragment of natural size and a portion of its surface x 18, showing the fully matured appearance of the zoarium. Coll. of E. O. U.
- Fig. 16. *Rhombopora incrassata*, ULRICH.-----p. 89.
 16. A specimen of the natural size and a portion of the surface x 18, showing the usual appearance in well preserved specimens of this species.

- 16a. A specimen doubtfully referred to this species, natural size, with a small portion of its surface x 18, showing the openings of one or more series of small pores between the zooecia apertures. Coll. of Prof. C. L. H.
- Fig. 17. *Rhombopora confuens*, ULRICH.-----p. 91.
17. A specimen of the natural size with a portion of its surface x 18. The small granulations shown near the bottom of the figure are seen on another specimen. Coll. of Prof. C. L. H.
- Fig. 18 and 19. *Streblotrypa* (?) *Leioclema* *denticulata*, n. sp.-----p. 88.
18. An unbranched fragment, natural size, with the surface x 18. The latter shows the denticulate apertures and striated interspaces characterizing the species
19. A branched specimen having the surface somewhat abraded, which is referred to the species. Natural size. Coll. of E. O.U.
- Fig 20. *Cystodictya angusta*, n. sp. -----p. 82.
20. Fragment natural size and a portion of the surface x 18, showing two rows of zooecia, irregular striations and fine granules. Also a transverse section x 6. Coll. of Prof. C. L. H.

GEOLOGY OF LICKING COUNTY, O. PART IV.

By C. L. HERRICK.

WAVERLY GROUP. Continued.

[General Conclusions.]

In concluding the list of fossils for the present it remains, in fulfillment of the promise made at the beginning, to express the opinions to which the study has led us. The discussion cannot be confined to Licking county and a large amount of collecting and stratigraphical study has been done in all parts of the Waverly domain in Ohio, as well as in Pennsylvania, and western New York. Only the briefest outline of this work could be admitted and the reader is asked to believe that the statements of fact presented have all been made after patient labor. Too many distinguished pens have already traversed the question for the writer to venture largely into speculation simply, but he is not without hope that some of the suggestions offered may meet the approval of those prepared to sift the evidence.

A great deal of confusion exists as to the actual sequence of strata in Ohio and the equivalence of beds in different parts of the state. No pains has been spared to determine the exact stratigraphical position of every fossil described and in this we have been unexpectedly successful. Our study sufficiently proves that in its various portions the Waverly presents the same sequence of species and that, casting aside a few species of great vertical range, these forms are rather sharply limited in definite horizons.

It is deeply to be regretted that for the purpose of correlating the horizons of the Waverly the reports of the Ohio Geological Survey are quite unavailable. Made up as they were by various hands, it is quite impossible to recognize a given horizon of one county in even the adjacent one. Diversity of nomenclature is the least of the difficulties encountered. It was of course impossible for this to be otherwise under the conditions imposed. It is hoped that the correlated horizons here presented may assist in supplying the deficiency.

Perhaps the greatest source of ambiguity in the report of the

- geologists of Ohio grew out of the attempt to construe certain local thickenings of the conglomerates of the Waverly. These we explain tentatively as deposits at the mouth of rivers and, in conformity to this theory, trace them as narrow bands of a tortuous character, extending, for example, north-westward from east Licking to west Knox and Richland counties. Wherever such disturbing factors enter, one seeks in vain for familiar landmarks, but a very few miles on either side reveals the well-remembered sequence. The term "Waverly conglomerate" of the Ohio geologists stands merely for such local developments and the admission of this element, often with the remainder of the series as seen near by, or occasionally without it, produces the most abnormal variations in the general sections.

This fact by no means depreciates the labors of the geologists in question, it was an unavoidable incident to the plan necessarily followed. Notwithstanding, for many purposes, just that opportunity to determine the relative position of a stratum in one part of the state with another in a distant county, is of greatest practical and theoretical importance.

Before beginning such a discussion as the present one it is well to have clearly defined the ruling principles upon which the investigation is based, we therefore premise the following:

GEOLOGICAL APHORISMS.

1. Palæontological determinations, to possess the highest value, must be accompanied by minute vertical and accurate geographical data.
2. Lithological determinations in sedimentary rocks are only valuable in connection with detailed palæontological and orographical study.
3. It must be remembered that the palæontological study of a single section, no matter how complete, gives no opportunity for the tracing of the genesis or history of a species. At most it gives only a series of disconnected instantaneous photographs of the species as it was at widely separated times under very diverse conditions.
4. To study the phylogeny of a group it will be necessary to follow it in its migrations as it continually seeks to preserve constant the fluctuating bathymetric conditions.
5. Strata of similar lithological character, even if separated by a considerable vertical interval, may more closely resemble each other

in fauna than those of different lithological character lying closer together or even between them. (That is, vital conditions may much more rapidly change along the shore than in deposits of the same age out at sea.)

Thus in the study of the phylogeny of the fauna of a shale, it should be compared with that of the next following shale and not of the intervening sandstone, but it must be remembered that the period intervening is probably represented by the deposits of the same bed in the direction of the encroachments of an ascending sea or the flight of a retreating one.

6. Opposite sides of the same basin may vary greatly in fauna.

4. Adjacent basins of the same age are rarely identical in fauna and it may be that the most abundantly represented species of these basins are unlike while the rarer species are identical, the latter therefore being most reliable age-indices.

8. It is to be expected that opposite sides of the same basin will possess vicarious species or varieties, and that corresponding sides of separate basins may be more nearly alike than adjacent sides.

9. Adjacent basins may have their strata intermingled along the margin through the agency of unequal oscillation of the sea bottom in the several basins. Then there will result the spurious appearance of an alteration of faunæ in one terrane when in reality, instead of the consecutive strata representing changes in one basin, they represent conditions in distinct sea basins,

10. Under favorable conditions, a local fauna may persist long after the normally associated groups have elsewhere perished.

The above are but a few of the many considerations which the student should bear constantly in mind in attempting the correlation of distant or even adjoining strata.

As a basis for further study let us briefly examine the Waverly series as it appears in central Ohio. The headings will sufficiently forecast the conclusions reached and the reader is asked to postpone judgment as to their correctness until after perusing what follows and examining the tables of distribution of species.

III. KEOKUK AND BURLINGTON GROUPS.

Upper Waverly. (Upper Logan.) Embracing shales and free-stone (the latter disappearing north-eastward) susceptible of subdivision into several tolerably distinct zones.

- (1). Ferruginous freestone (Keokuk ?) with *Phillipsia meramecensis*, *P. serraticaudata*, *Aviculopecten rushvillensis*, *Spirifer Keokuk* ? - - - - - 10 ft.
- (2). Shales with *Shuzodus newarkensis*, *Productus semireticulatus*, *P. burlingtonensis*, many bryozoa, *Macrodon newarkensis*, *Grammysia ovata*, etc. - - - - - 20 ft.
- (3). Freestone with *Productus arcuatus*, *Conularia newberryi*, etc. - - - - - 10 ft.
- (4). Shales and freestone with *Centronella*, *Spiriferina*, etc. 35 ft.
- (5). Shales with *Lingula scotia*, *Lingula gannensis*, *Orbiculoidea pleurites*, *Ctenodonta houghtoni*, etc. - - - - 5 ft.

II. KINDERHOOK. (part or all) Middle Waverly.

- (6). Conglomerate II, with *Spirifer winchelli*, *Dexiobia ovata*, *Phaethonides occidentalis*, *Syringothyris cuspidatus*, etc.
- (7). Shales with *Sanguinolites obliquus*, *Allorisma winchelli*, *Prothyris meeki*, *Grammysia ventricosa*, etc. - - - 7 ft.
- (8). Freestone with a parting of shale and many fossils. *Crenipecten winchelli*, *Proetus auriculatus*, *Rhynchonella marshallensis*, *Syringothyris cuspidatus*, *Goniatites lyoni*, *Spathella ventricosa*. - - - 30 ft.
- (9). Shale, fossils as above but rare. - - - 15 ft.

I. TRANSITION ZONE. Devonian. In part equivalent to Che-mung and Portage.

- (10). Conglomerate I, (variable) with *Spirifer deltoideus*.
- (11). Shale with *Palæoneilo attenuata*, *P. elliptica*, *Nucula iowensis*, *N. stella*, *Sphenotus flavius*, etc. - - - 30 ft.
- (12). Flags and shales with *Leiopteria ortonii*, *Crenipecten subcardiformis*, etc. - - - 10 ft.
- (13). Shales and flags, very fossiliferous, with *Spirifer marionensis*, *Proetus præcursor*, *Productus shumardianus*, *Conularia gracilis*, *Entolium shumardianum*.
- (14). Flags and shale nearly unfossiliferous (with number 13). About - - - 225 ft.
- (15). Soft greenish shales with *Palæoneilo consimilis*, *Schizodus* sp., *Spirifer* resembling *S. disjunctus*, *Proetus* sp., *Pleurotomaria*, etc. - - - 10-20 ft.

- (16). Siliceous flags with *Atrypa reticularis* and *Strophomena rhomboidalis*. Fifty or seventy-five feet of this constitutes the Berea grit proper, which is separated from the remainder in many places by a thin seam of bitumenous shale containing *Lingula melie* and *Orbiculoidea meeki*.

BEDFORD SHALE. (Hamilton facies in Chemung association.)

Upper portion, chocolate shales - - - - - 40 ft.

Lower portion, greenish shales with very numerous fossils, *Palæoneilo bedfordensis*, *Macrodon hamiltonæ*, *Microdon bellistriatus*, *Chonetes scitula*, *Orthis vanuxemi*, etc. - - - - - 15 ft.

BLACK OR HAMILTON SHALE.

The lower division cannot greatly exceed 500 feet, the middle division measures less than fifty feet, the upper one hundred and twenty-five.

To indicate that the section above given is not local and accidental but represents the typical sequence in the larger part of the state we may compare three favorable localities as distant as possible. We select Sciotoville in the southern part of the state and a magnificent exposure near the western line of Ashland county to represent the northern, while Rushville as supplemented by western exposures, represents the central. The Ashland section is first given.

We venture to place in parallel columns the section actually measured in continuous exposure and that published in the Ohio Geological Survey report as a correlated section in the same part of the state.

NEAR LYON FALLS

Unexposed.....	20 ft.
Ferruginous zone with <i>Phillipsia serraticaudatus</i> , etc.....	10 ft.
Shales and freestone.....	20 ft.
Freestone, fossils of upper Waverly.....	10 ft.
Shales and freestone.....	8 ft.
Massive freestone with <i>Productus arcuatus</i>	10 ft.
Shales and freestone.....	50 ft.
CONGLOMERATE II.....	18 in.
Sandy shale, <i>Prothyris meeki</i> , <i>Alorisma</i> , etc.....	5 ft.

OHIO GEOLOGICAL REPORT.

Carboniferous conglomerate.
Argillaceous and siliceous shales
----- 170-250 ft.

NEAR LYON FALLS.

Shale.....	3 ft.
Freestone with a parting of shale, Syringothyris.....	27 ft.
CONGLOMERATE I.....	18 in.
Shaly and siliceous layer.....	10 ft.
Blue shale "lamellibranch layer?" siliceous flags.....	30 ft.
Concretionary shale with <i>Spirifer</i> <i>marionensis</i> , etc.....	30 ft.

OHIO GEOLOGICAL REPORT.

Waverly conglomerate.....	100-190 ft.
Argillaceous and sandy shales, sometimes bitumenous.....	65 ft.
Shales with bands of flaggy sand- stone.....	295 ft.
Berea sandstone.	

This section corresponds, with a variation of only a few feet, with that seen below Rushville as far as exposed, that is to the conglomerate II, below which it agrees essentially with the Licking county exposures. The calcareous nodules and surrounding shale contain a rich fauna exactly equivalent to the Moot's run horizon (No. 13.) being characterized by *Spirifer marionensis*, *Streblopteria fragilis*, *Pterinopecten cariniferus*, etc. The freestone is somewhat contracted and less fossiliferous and shows premonitory symptoms of its decline further north-east. Further west in Richland and Knox counties one or both of the conglomerates are thickened at the expense of the remaining strata.

Sciotoville.	Rushville, Etc.	Ashland Co.
Carboniferous Congl.	Chester limestone.	
	Sandy shales.....	
	Freestone, <i>Phil. mermacensis</i> , <i>Phil. serraticaudata</i>	Shales, <i>Phil. serraticaudata</i>
		20 ft.
Freestone and shales, <i>Spirifer striatiformis</i>	Shales and freestone <i>Spirifer striatiformis</i> , <i>Schizodus newarkensis</i>	Freestone and shale, <i>Spirifer striatiformis</i>
50 ft.	Shale.....	30 ft.
	Freestone, <i>Prod. arcuatus</i> , etc.....	Freestone, <i>Prod. arcuatus</i>
Freestone with <i>Productus arcuatus</i>	10 ft.	18 ft.
Shale.....	Shale.....	Shales.....
	30 ft.	50 ft.
(CONGLOMERATE II.)	CONGLOMERATE II.	CONGL. II.....
Freestone.....	Shale, <i>Sanguinolites obliquus</i> , etc.....	Shales, <i>Sang. obliquus</i>
20 ft.	7 ft.	5 ft.
Shale.....	Freestone, <i>Syringothyris</i> <i>cuspidatus</i> , <i>Proetus auriculatus</i>	Freestone, <i>Proetus auriculatus</i> , <i>Syringothyris cuspidatus</i>
20 ft.	30 ft.	27 ft.
Freestone <i>S. cuspidatus</i> , etc.	Shale.....	Shale.
	15 ft.	

Sciotoville	Rushville, Etc.	Ashland Co.
(CONGL. I, absent.)	CONGLOMERATE I.	CONGL I18 in.
Shales40 ft.	Shales, Palaeoneilo attenuata, etc. 30 ft.	Flags and shale ..10 ft.
	Shales and flags.40 ft.	Siliceous flags...30 ft.
Spirifer marionensis, shales and flags, 70 ft.	Shales concretions, Spirifer marionensis.30 ft.	Concretionary shales, Spirifer marionensis,30 ft.
	Flags and shales.....70 ft.	
	Flags, unfossilif.125 ft.	
	Shales, fossils.....10 ft.	Flags and shales.
	Berea grit, etc.100-175 ft.	

Our own observations are less full and connected further north, and a marked lithological change accompanied by the gradual disappearance of many of the mid-Waverly horizons produces a somewhat peculiar habitus as we enter the Cuyahoga valley. The few feet of shale near the top at Cuyahoga Falls seem to extend above any of the southern horizons and mingle fossils like *Spirifer buplicatus* of the Waverly with coal-measure types like *Entolium aviculatum*. The mistake has been made of regarding these shales as homogeneous. An almost entire change in fauna appears a mile or two below Cuyahoga Falls and there is little in common between the upper shales and those below the flags forming the second falls of the Cuyahoga. The following section is given by Dr. Newberry in Summit county :

Conglomerate. (Base of coal-measures)	
Cuyahoga shale.....	150-200 ft.
Berea grit.....	60 ft.
Bedford shale.....	70 ft.
Cleveland shale.....	50 ft.
Erie Shale.....	100-125 ft.
Huron shale.....	

The entire section, including the Erie and Cleveland shales which disappear further south, is less than 500 feet, and, making the necessary allowance, about 350 feet will include all of the Waverly which has an equivalent represented in central Ohio.

We may now pass to a more detailed study of the recognized horizons in Ohio.

1. *The Cuyahoga shale and Logan group.*

The term Cuyahoga shale is most misleading and can serve only to indicate the condition of the geological column in the northern tier

of counties. Instead of being a homogeneous unit of this column it is itself a curious patch-work mingling the most diverse elements of the series as seen further south and yet possessing a certain unity, due chiefly to the lithological similarity and hence the similarity in conditions of deposition of its various strata. Prof. Orton has called attention to this error as indicated by the lithological diversity of the various elements which Prof. Newberry's name is made to include, but we can more emphatically repeat his strictures from the standpoint of palæontology. The upper part of the series possesses a sub-carboniferous character and can be almost certainly parallelized with the shales in the upper part of the section as it appears in Licking county though it has some elements belonging to itself. *Conularia newberryi*, *Nucula houghtoni*, *Spirifer biplicatus*, *Entolium aviculatum*, *Spirifer setigera*, *Crenipecten*, sp. *Phillipsia immaturus*, etc., are among the common fossils.

This upper portion has been thought to be devoid of fossils but will yield a good harvest to the patient collector. It must not be confused with the lower fossiliferous horizons of Bagdad, Lodi and Weymouth. The fossils of this horizon are in part shown upon Plate X, Figs. 2—28 and 36—40. This layer lies *only forty feet below the conglomerate* at Cuyahoga Falls. The concretionary shales at Lodi and Weymouth extend *over one hundred feet* below the carboniferous conglomerate and present us with a very different association of fossils, the lower part of which contains some elements of a like concretionary zone of thirty or forty feet in thickness in Ashland county, there seventy feet below conglomerate I and one hundred and eighty feet or more below the carboniferous conglomerate and at least one hundred and fifty feet below the strata regarded as equivalent to the Cuyahoga shales. This latter horizon can be seen at Moot's run in Licking Co., where it is about two hundred and fifty feet below the carboniferous conglomerate.

The whole middle Waverly as seen in the central and southern part of the state is absent or only here and there present in its shaly strata. The equivalent of the shale below conglomerate II may be seen in parts of Medina county but only locally fossiliferous. That portion of the Cuyahoga shale below this concretionary layer is as yet insufficiently known, but contains four species of *Lingula* and will ultimately prove fruitful. Where it reposes on the Berea it bears *Lingula melie*, and *Orbiculoidea newberryi*, as it does in central Ohio and, as

there, tends to develop bitumenous bands. The fact that the Crinoids of Richfield are essentially Burlington species is not surprising in view of the fact that the strata represented by the Upper Cuyahoga in central Ohio are purely carboniferous with evident Burlington alliances. The evidence on this point afforded by the report of Mr. Ulrich, printed in this number is especially important. We can safely assert that the crinoids of the Cuyahoga shales in northern Ohio indicate an age not earlier than Burlington, the bryozoa of the same horizon in northern, central and southern Ohio indicate an age corresponding to the Keokuk and Burlington while the Logan fossils of other groups, for example, *Phillipsia meramecensis*, indicate the same age. We submit therefore, that the upper one hundred feet of the Waverly are no longer doubtful—they are certainly of Carboniferous age and contain a fauna extending from the Burlington into or through the Keokuk groups. The term "Cuyahoga shale" can only be retained as a topographical designation.

Prof. Orton, with some reservation in view of further observation, suggests a division of the Cuyahoga shale into an upper and lower division, for the first of which he uses the term Logan, retaining the name Cuyahoga shales for that part below the conglomerate I, and extending to the black or Berea shale containing *Lingula melie*. To this, two suggestions must be offered. First, the term Cuyahoga shale was applied especially to the upper part, as all the writings of Newberry show, and this upper portion actually contains a part of the proposed Logan. Second, the Logan is both lithologically and faunally composite and consists of a number of distinct portions which are in fauna more unlike than the lower shale and the Logan. We have shown already at sufficient length the nature of the distinctions between the upper and middle divisions. The term "Waverly conglomerate" is especially unfortunate as the developments of conglomerate, as already shown, are local and may represent either conglomerate I or II, which are separated by a long and important interval.

In view of the above considerations we suggest the following modification of Prof. Orton's scheme, hoping to avoid the difficulties incident to the earlier plan of Dr. Newberry without introducing ambiguity into the terms employed :

"Cuyahoga or Waverly series."	{	Logan { Keokuk	100-150 ft.
		{ Burlington	
		(Conglomerate II.)	
		Kinderhook 50-60 ft.	
		(Conglomerate I.)	

<i>Berea or Transition series.</i> (Western equivalent of upper Chemung.)	{ Waverly shale.....	40 ft.
	{ Berea shale*.....	200-400 ft.
	{ Berea grit.....	50-60 ft.
	{ Bedford shale.....	50 ft.
<i>Erie shale,</i> Eastern or typical Chemung (lower part).....	{ Cleveland shale(local).....	50 ft.
		100 ft.

2. *The Middle Waverly or Kinderhook Division.*

In as much as this important division is quite absent in the northern and eastern localities, a great deal of misapprehension has arisen which is quite uncalled for. The geologists who have worked only in the Cuyahoga valley habitually under-estimate the significance of this the most fossiliferous portion of the series. The middle Waverly is essentially a littoral zone and its fossils are for this reason largely peculiar, but it can be readily shown that Prof. Alexander Winchell was correct in identifying this horizon with the Kinderhook, etc., of the west. We do not claim that no fossils of the Kinderhook occur above conglomerate II or below conglomerate I, for this would be contrary to all analogy, but we do believe that, as a rather distinct factor of the Ohio Waverly, this may be wholly referred to that age and is its specific equivalent. That this horizon is equivalent to the Catskill of New York, as suggested by Winchell, would be in our judgement too specific a claim. The Catskill is another such a local development but it is more intensely local as it is a restricted member of the Chemung series, itself a littoral and provincial deposit. Very strict correlation of strata deposited under diverse conditions may never be possible. Chronological and faunal equivalences are rarely strictly identical. We may safely say that our middle Waverly is *representative of* the Catskill, and that is enough. It is not necessary to rehearse the accumulated evidence to show that this group is more closely allied to the upper Chemung than the Carboniferous limestones of the west. The species which give to the Waverly its carboniferous aspect as maintained by all writers, are largely from division iii. Nevertheless, the transition is gradual and almost imperceptible. The following are a few of the species which substantiate the identity with the Kinderhook. (It should be observed that the fossils of the lower sandy portions of the Burlington have been referred to the Kinderhook, hence quite a number of so-called Kinderhook species occur in our division iii). Conocar-

*This term includes not only the black shale, so called by Prof. Orton, but the greater part of the shales below the Kinderhook.

dium pulchellum, *Nucula iowensis*, *Sanguinolites rigidus*, *Spathella ventricosa*, *Mytilarca fibristriata* (below), *Dexiobia ovata*, *Syringothyris* sp., *Edmondia burlingtonensis*, *Goniatites lyoni*, *Murchisonia quadricincta*, *Bellerophon cyrtolites*, *Productus arcuatus*, *P. Shumardianus*, *Chonetes logani*, etc.

3. *The Haverly Shale.*

This term is given to forty feet of very fossiliferous shale below conglomerate I, and perhaps most closely related to our division II. The fossils are generally identical with Michigan species, such as, *Palæoneilo attenuata*, *P. elliptica*, *Orthonota rectidorsalis*, *Sanguinolites unioniformis*, etc. This section contains a number of Kinderhook species with a sprinkling of those of the preceeding horizons. We have for convenience classified it with the Berea or Transition series.

4. *The Berea Shale.*

This is equivalent to the Cuyahoga shales of Orton minus the above mentioned shale. Instead of being as Prof. Orton states almost unfossiliferous, this division is one of the most interesting in the state, preserving its fossils, thanks to the calcareous concretions, in perfect condition. The species are mostly new to science but have analogies with Chemung and Hamilton forms. The bryozoa have not furnished conclusive evidence, most of them being new. The upper thirty or forty feet contain the concretions with three or four new trilobites, and *Spirifer marionensis*, *Fenestella herrickana*, *Lyriopecten* ? *cancelatus*, *Pterinopecten cariniferus*, *Streblopteria fragilis*, *Promacra* ? *truncata*, etc., are characteristic species. Traces of the same fauna can be followed downward over 100 feet. The lower part of this shale to the Berea contains a fauna as yet unstudied. The difficulty of securing specimens is extreme. Several days labor during which the shale was systematically examined bit by bit, inch by inch, have yielded about half a dozen species in obscure fragments. A *spirifer* apparently intermediate between *Sp. marionensis* and *Sp. disjunctus*, a *Chonetes* like *C. scitula*, a *Palæoneilo* like *P. sulcatina*, a *Schizodus* somewhat like *S. medinaensis*, a fine *Pleurotomaria*, *Palæoneilo consimilis* and a *Proetus* being the entire find. The patient student will perhaps secure added material from exposures of this horizon one mile east of Harlam and four miles west of Jersey.

5. *The Berea Grit.*

The thickness of this horizon varies considerably. The grit proper

rarely exceeds sixty feet, but the superposed shales frequently become flags resembling it closely. These flags have yielded *Atrypa reticularis* and *Strophomena rhomboidalis*, the latter species, however, in the undisturbed deep sea fauna farther east, endured until the beginning of division iii. The only other fossils known from the Bera grit are found in the bitumenous layers overlying the grit. They are *Orbiculoidea newberryi* and *Lingula melie*.

In the northern part of the state the Berea is more distinct and may be divided into the lower or grind-stone grit and the upper or flag-stone division. The following section in Lorain and Medina counties will sufficiently illustrate the relations :

Carboniferous conglomerate.....	25 ft.
CUYAHOGA, etc. {	
Shales with <i>Chonetes illinoisensis</i> , numerous bryozoa, etc.....	65 ft.
Flags and shales with <i>Spirifer biplicatus</i> , <i>Productus newberryi</i> , etc	35 ft.
Ferruginous freestone with many fossils	20 ft.
(Middle Waverly, absent.)	
WAVERLY AND BERE SHALES {	
Shales with concretions with <i>Strophomena rhomboidalis</i> and fossils of horizon 80 feet below congl. I mingled with those of division III.....	30 ft.
Unseen (perhaps).....	150 ft.
BEREA GRIT. {	
Berea flags.....	40 ft.
Grindstone grit.....	20 ft.
BEDFORD SHALE, (green and red).....	50 ft.

6. *The Bedford shale.*

This member of the series has been the occasion of much perplexity. The so-called chocolate shales of central Ohio have frequently been identified with the Bedford of the lake region upon lithological grounds alone, the southern exposures being thought unfossiliferous. As a matter of fact, they are everywhere abundantly fossiliferous. Especially prolific exposures occur near Central College, O. A number of the species occurring there are figured on Plate IX, and several of the same species are abundant in Summit county near Peninsula. One is at once struck by the fact that the group of forms here associated has nothing in common with either the Erie shale fauna or that of known exposures of the Waverly. The stratum rests directly on the the Hamilton* for much of its extent but overlaps the Erie shales in the north-eastern counties. Another fact is equally striking. The

*Prof. Orton, indeed, identifies the Cleveland shale in central Ohio, but in this we are unable at present to concur.

species are indistinguishable from or very like well-known Hamilton *forms*.

LIST OF FOSSILS FROM THE BEDFORD SHALE.

1. *Lingula melie*, H.
2. *Orbiculoidea newberryi*, H.
3. *Orthis vanuxemi*, H.*
4. *Chonetes scitula*, H.*
5. *Ambocoelia umbonata*, H.*
6. *Hemipronites*, sp.
7. *Macrodon hamiltona*, H.*
8. *Microdon bellistriatus*, Con. *
9. *Leda diversa*, var. *bedfordensis*, var. n. (*)
10. *Palæoneilo bedfordensis* (=var. of *P. constricta*,)
11. *Pterinopacten*, sp.
12. *Bellerophon newberryi* ? (*)
13. *Bellerophon lineata*, H. ?
14. *Loxonema*, sp. (resembling *L. delphicola*.)
15. *Orthoceras*, sp. (resembling *O. linteum*.)
16. *Goniatites*, sp. (resembling *Portage* sp.)
17. *Pleurotomaria* (cf. *sulcomarginata*.)

One might conclude at once that this shale is little later than the Genessee but what seems like a well-warranted conclusion is quickly disturbed by the facts known concerning the subjacent strata in northern Ohio.

As above stated the Bedford repose on the Black shale in central Ohio, but along Lake Erie two important members are interpolated, viz., the Cleveland and Erie shales.

Dr. Newberry has decided that the Bedford shale is carboniferous on the basis of such fossils, as *Syringothyris typa*, *Hemipronites crenistria*, *Chontes logani*, *Orthis michelina*, and *Spiriferina solidirostris* and a few more. Having searched in the same localities without finding these forms in the typical Bedford as it appears in southern Ohio and on the other hand finding the species above mentioned we feel some hesitation as to the occasion of the confusion. These species may indeed occur below the Berea, but in flags and greyish shales *not in the blue or red Bedford shale* !

*Species so designated are of Hamilton age or closely related to such species.

6. *The Cleveland shale.*

This is a local bitumenous phase of great interest on account of the fish remains found in it. It may be omitted from our discussion as a local development reaching only the thickness of fifty feet and rapidly thinning out to the south. But that fact, and the fact that the Erie also becomes thicker to the north-east while the remaining strata grow thicker toward the south-west may occur to us in the light of a valuable suggestion. Meanwhile we pass to

7. *The Erie shale.*

This has been a bone of contention. Probably the Devonian content of the lower Waverly would be admitted by everyone were it not that the fauna of the Erie is undoubtedly Portage or Chemung. It has yielded us, in the Cuyahoga valley near Peninsuala, the following species:

1. *Spirifer altus.*
2. *Spirifer disjunctus.*
3. *Spirifer prænaturus.*
4. *Leiorhynchus mesacostalis.*
5. *Streptorhynchus chemungensis.*
6. *Terebratula*, sp.
7. *Rhynchonella sappho.*
8. *Leiopteria*, sp.
9. *Orthoceras bebryx.*
10. *Productus* (like *lachrymosus*.)

To this list Prof. Newberry adds *Orthis tioga*, and others of unmistakable Chemung age. Dr. Newberry, in a private letter dated May 28th, 1888, reiterates the conclusions arrived at on the Geological Survey of Ohio, stating that "there is no foundation in fact for the union of the Cleveland, Erie, and Huron shales as the Ohio Black Shale. The Cleveland and Huron have nothing in common and in eastern Ohio are separated by 1000 feet of Erie shale which is upper Portage and Chemung. It (the Huron) represents everything in New York, from the Gardeau shale to the Marcellus inclusive, as I have taken from it in central and western Ohio fossils of the Portage, the Genesee, and the Marcellus shales, viz: *Goniatites complanatus*, *Leiorhynchus quadricostatus*, *Lingula spatulata*, *Discina lodensis*, *Lunulicardium fragile*, *Styliola fissurella*, and *Leiorhynchus limitaris*."

The aspect of the Erie shale is exactly that of the Waverly shale

above the Berea and there seem to be several identical species but our time was too brief to collect systematically. A species of *Syringothyris* at least seemed to be common. The Bedford shale on the other hand seems more to resemble the Huron and in some places where it lies superposed on it is difficult to distinguish. Were it possible that this close interblending had escaped Dr. Newberry it would seem probable that some of the species attributed to the Huron are really Bedford.

All discussion of the age of the lower Waverly now turns upon the question as to the age of the Erie and Bedford, and this question stands in need of careful field-work and especially more extended and minute palæontological examination. Meanwhile the following suggestions may be hazarded. First, we may assume as proven that the Erie shales are of Chemung age, that is, in the broad sense, including Portage. The fossils, on the whole, indicate lower Chemung or Portage. Are we to conclude from this that all which lies stratigraphically above the Erie is certainly later faunally than the top of the Chemung as seen in New York strata? We think this does not by any means follow. We are struck in examining the stratigraphy of the Waverly by the fact that the dip of the true Waverly strata is south-east and the great area of its deposition is in a different basin from the Chemung. The Waverly strata thin out to the north-east while the Erie increases in thickness in the same direction. The point where the Erie and Waverly strata come into juxtaposition is not, however, along the shore of the Waverly sea, but far to the eastward of the littoral deposits. The two sets of rocks were formed then by different but occasionally interblended seas. The line of strike measurably conforms to the shore line in the Waverly. Thus the plane of 1000 feet elevation intersects the Moot's run horizon in Licking county and some distance west of Portsmouth in southern Ohio, while at Lodi the same horizon seems nearly at 825 feet probably, throwing the line of intersection further toward the west. There has not been any considerable change of level since the sediments were deposited beyond the gradual sinking of the centre of the basin. It is evident that the Devonian basin in New York and that of the Carboniferous in Ohio are not coincident nor have their movements followed the same rhythm.

When the strata which constitute the Chemung in New York were forming, what was going on in Ohio?

There seems to have been a pretty general uniformity of condi-

tions during the Hamilton period over the entire area considered—indeed a much more extensive one. The change which made the sediments of New York littoral sands and induced a modification of fauna may not have been felt at once in distant areas in Ohio. The undisturbed seas in Ohio may have been concealing a fauna closely allied to the Hamilton, while the oscillation along the western border of the Chemung area may have once and again thrown a great apron of its own sediments over Hamilton beds, only to be in turn covered by a similar apron from the Ohio ocean.

What, indeed, is to prevent us from believing that when the early fluctuation of the north-eastern part of this area was bringing more and more of the Silurian shore-line within its own erosive power and accumulating coarse detrital material in great masses, the weedy sea of the Hamilton continued unaltered in Ohio. Sandy bottom, stormy waves and unaccustomed conditions of all kinds must have their effect on the organization of the fauna and, if accepted ideas of the causes of evolution are correct, a sudden change would be seen in a faunal development more or less forced, one-sided, and local.

Great variety within narrow groups is the rule under such conditions. Just as the sudden formation of a prairie out of a morass develops hundreds of species in a few genera, so, in this case, such groups as could cope successfully with the new conditions would expand while others disappear. As the agitation extended westward the plot thickens. Somewhere on the western part of our area we should expect to find strata strangely interblended, just as a player in cutting and shuffling a pack thrusts the edges of the cards between each other. Here we should find a stratum marking the return of the former conditions.

Such a state of things as we have supposed would explain the conditions in northern Ohio in the period before the Berea grit, which put an end to all this by calling in the agency of shore action on its own account in the western part of the basin. Of this there is abundant evidence in the oblique lamellation and fucoids of that horizon. If we admit the probability that Hamilton and New York Chemung played a game of hide and seek during the preliminary oscillation they certainly were sadly disturbed during the Berea epoch.

Then followed a gradual depression with occasional infiltration from the Chemung area, now rapidly contracting. The Berea shales mark the long period of isolation and gradual depression. When the

subsequent upheaval began the sea must have extended as far as to the northern highlands and, after gnawing away at their bases and storing up great reservoirs of material, there began the gradual depression which spread them over the whole of the area. Time was then ripe for the opening of the Carboniferous period. The old descendants of Hamilton forms had done what they could, assisted by strays from the Chemung areas further east and having grown sadly out of fashion they were now subjected to nearly the same influences which were applied in the Chemung area. Littoral action and coarse sediments soon bore fruit in a fauna very like the later Chemung, though that period was now closed in New York.

Thus grew up our Kinderhook or middle Waverly. But a temporary recession swept the waters backward depositing a shale containing a few descendants of the old Waverly-shale fauna with interspersed forms of Carboniferous types. It was now sub-carboniferous time and the elevation which next followed left its trail of sandy material with a fauna not unlike the Burlington but so hastily retreating as to build no limestone fortifications. But in the far south-east now these limestones gathered strength and with the next gain of Neptune flung a thin apron over the lap of southwestern Ohio into which stormy Coal-measure seas cast millions of tons of stones worn by the universal torrents from the northern shores.

Of course this is a fabric of the imagination, but does it not explain in some measure rationally the complicated problem of the Waverly?

There can be little doubt that the materials of middle Waverly sandstone and conglomerate were carried by rivers or the like. The epoch of coal-measure conglomerate we have also spoken of as a torrent period. On what grounds? 1st. The accumulation of tree trunks of carboniferous aspect. 2nd. The nature of the deposits. 3rd. The fickle distribution of the materials. 4th. The combination of new and old material in its make-up, etc. How is the sudden and simultaneous advent of this rainy season explained? Did we not hear but yesterday that the axis of mother earth took a tilt northward disturbing all conditions? May not the inauguration of this change have been a gusty epoch? Incidentally we have showed how the composite character of the upper part of the Cuyahoga shale is to be understood.

It is not intended to carry out this speculation so far as to formulate an hypothesis. To the experienced student the few hints offered

may be sufficient to indicate at least a partial escape from the apparent dilemma introduced by the results of palæontological study*.

ADDENDA.

PTERINOPECTEN LÆTUS. H.

(Plate V, Fig. 13.)

A single left valve which cannot be distinguished from the quoted Portage species, was found at Moot's run.

SPIRIFER KEOKUK.

Specimens of this or a closely allied species occur in the upper layers at Rushville and Loudonville.

LEIOPTERIA ?? NEWBERRYI, *p. n.

(Plate XI, Fig. 31; also Vol. III, Plate VII Fig. 36)

This species is anomalous, at least we know no close analogue in any Carboniferous or Devonian genus. From any of the species here described it may be distinguished by the great height and uniform

*Prof. Orton's statement that the Cleveland shale is identified in central Ohio, is contrary to all statements of other geologists and apparently very slightly supported by observation. There is a considerable lithological difference between the Cleveland shale of northern Ohio and the Huron near Columbus, though Prof. Orton identifies one with the other, apparently without regarding the difficulty of disposing of the great Erie shale with its Chemung fossils, which separates them at the north.

It is not at present possible either to affirm or deny the extension of the Erie to the south-east, as the testimony of drilled wells is very ambiguous where minute differences and especially when palæontological considerations are in question.

A glance at Prof. Orton's useful map and sections of the Berea will strongly reinforce the view here presented. The south-eastward extension of the Waverly basin as contrasted with the north-eastward extent of the Chemung area is very obvious. The thickening of the Erie and Cleveland shales will be seen to correspond nearly to a change in dip, the line of which forms an anticlinal south of Akron, etc. So far as can now be gathered the red or true Bedford shale does not extend far to the north-east in Ohio. The great thickening of the Berea grit to the north-east is additional evidence of the near proximity of the shore of the Berea sea. At Youngstown there are about 150 feet of Berea, at Martin's Ferry 130 feet.

convexity of the posterior margin. The beak is about one-fourth from the anterior extremity. Anterior margin short, oblique, terminating in a rather acute angle at the lower margin, which is gently curved. The hinge-line is oblique to the axis and nearly straight. The surface is quite convex and marked only by concentric lines of growth.

It is possible that the species is related with *Spathella* or *Modiola* rather than *Leiopteria*. A second species or variety is figured on Plate V, Fig. 12, of vol. III. This is proportionately more elongate and has the lower outline somewhat sinuous at a point near the front where a sinus passes over the surface toward the umbo. The posterior wing is also more strongly extended, yet we suspect these both fall in a single species. The first above described form is apparently from the highest horizon of Div. III, i. e., Keokuk or upper Burlington, while the latter is from a lower zone in the same division at Newark. Comparative measurements may be taken from the figures as the specimens are not now available.

AVICULA ? RECTA. sp. n.

(Plate X, Fig. 13.)

Shell scarcely oblique, broad and flat, expanded below; hinge about one-half the height; posterior wing small, obscurely rounded, posterior margin nearly straight, forming an angle of about 15° with the hinge; anterior wing large, nearly rectangular, separated from the body by a depression forming an angle of 45° with the hinge, anterior outline with a shallow sinus at the juncture of the ear and body; front margin broadly elliptical. The surface is marked by strong, unequal, concentric grooves and striæ. Length of hinge, 6.5 mm.; height, 12 mm.; greatest length 10 mm.

Cuyahoga shales at Cuyahoga Falls, 30 feet below the conglomerate.

SOLENOMYA ?? CUYAHOGENSIS. sp. n.

(Plate X, Fig. 1.)

Shell minute, resembling in most ascertainable characters *S. andontoides* of the coal-measures, but less expanded posteriorly. This may prove to be a young specimen of an *Edmondia*. I will not give a formal description but refer to the figure for all known details. Length, 6 mm.; height, 3.5 mm. Cuyahoga Falls, 30 feet below the conglomerate.

SCHIZODUS TRIANGULARIS, Her.

(Plate VI, Figs. 10, 13.)

Macrodon ?? triangularis, HERRICK. Bul. Den. Univ. vol. III, p. 74, Plate VIII—
Fig. 8.

The poor specimens encountered last year gave an entirely false impression of this species. We have figured two typical (but, in size extreme) examples of the species which show that the specimen figured last year, like many others seen, had lost the narrow posterior margin. The description may be emended as follows:

Shell large, sub-triangular in outline, apparently unusually thick for the genus. Hinge-line very short; anterior margin nearly straight or even slightly concave with the antumbonal convexity apparently springing abruptly from the edge, which forms a large angle with the hinge; posterior margin nearly straight, very oblique to the hinge very near the post-umbonal ridge, post-umbonal slope very strong lower outline a gentle convex curve broken by a slight sinus posteriorly. Surface convex, with a shallow groove in front of the post-umbonal ridge, which is strongly marked.

The very narrow and strongly depressed post-umbonal portion is characteristic of the species and, as even this was hidden or broken off in all of our earlier specimens, the resulting form seemed quite anomalous. This species seems so unlike the associated species as to require no comparison. It is limited to the freestone of the middle Waverly.

PLEUROTOMARIA STELLA, Win?

(Plate X, Fig. 41.)

"Shell minute, trochiform, composed of four and a half closely opposed whorls, forming an apical angle of about 90°. Suture linear, inconspicuous, the flat sides of the whorls all lying in the same plane. Body whorl regularly rounded, marked by a raised bilinear band situated a little above the peripheral line, and on the whorls of the spire nearly concealed. The body whorl is ornamented by a line of minute tubercles running close to the suture, and occupying a feeble revolving ridge. No indications can be seen of transverse striæ connected with the tubercles.

Aperture subcircular; with the columellar lip reflected over the umbilicus. Some sharp incremental lines rise from the umbilical de-

pression and extend across the body of the shell. Height, .16 in.; width, .20; height of body whorl, .14; height of aperture, .9; width of band at aperture, .02; number of tubercles in one-tenth inch, 12."

Though somewhat larger our specimen agrees in all visible characters with the Michigan species.

From shale above conglomerate II, at Newark, where it is associated with *Orbituloidea pleurites*, *Lingula waverlyensis*, *Atorisma consanguinatus*, *Cohularia newberryi*, etc.

SCHIZODUS HARLAMENSIS, sp. n.

(Plate VI, Fig. 2.)

Shell small, subtrigonal, considerably longer than high, rather flat; beak prominent and produced; anterior side nearly at right angles with the basal and hinge margin, abruptly rounded above and below; lower margin nearly straight and parallel to the hinge; posterior margin but slightly oblique, moderately curved; central lower surface a triangular plane, posterior to which the post-umbonal slope slopes as a more oblique plane to the margin, while the ant-umbonal portion is more convex. Surface smooth except for the usual fine concentric striae. In this species we see a link between Chemung and Waverly forms, if indeed, this does not prove identical with a Chemung form. The resemblance to *Schizodus medinaensis* is unmistakable. One mile east of Harlam, Delaware Co. In shales a few feet above the Berea flags.

PLATE I.

Figs. 1-3.	<i>Proetus</i> (<i>Phillipsia</i> ?) <i>præcursor</i> , Her.	p. 54.
Figs. 4-5.	<i>Phaethonides spinosus</i> , Her.	p. 58.
Fig. 6.	<i>Phillipsia meramecensis</i> , Shum.	p. 54.
Fig. 7.	<i>Proetus minutus</i> , Her. Camera drawing of nearly perfect individual, highly magnified	p. 56.
Fig. 8.	<i>Phillipsia serraticaudata</i>	p. 52.
Figs. 9-15.	<i>Phaethonides immaturus</i> , Her.	p. 59.
Fig. 10.	<i>Phaethonides occidentalis</i> , Her.	p. 57.
Fig. 11.	<i>Phillipsia serraticaudata</i> ?? hypostome	
Fig. 12.	<i>Proetus</i> (<i>haldemani</i> ?)	p. 55.
Fig. 13.	<i>Proetus</i> (<i>Phillipsia</i>) sp. close to <i>P. auriculatus</i>	p.
Fig. 14.	<i>Proetus</i> (<i>Phillipsia</i>) <i>ariculatus</i> , H. (= <i>shumardi</i>)	p. 54.
Fig. 16.	<i>Phillipsia</i> (?) <i>consors</i> , Her.	p. 53.

PLATE II.

- Fig. 1. *Hemipronites crenistria*, 10 ft. above Ohio river at Sciotoville.....p. 2
 Fig. 2. *Spirifer marionensis*, Portsmouth.....p. 2
 Fig. 2a. Surface characters, highly magnified.
 Figs. 3-10. *Spirifer* (resembling *altus*) Moots' run, calcareous concretions.
 Fig. 4. *Spirifer* (*tenuispinatus*) sp. n. Moots run.....p. 2
 Fig. 5. *Hemipronites*. Young individual. Moots run.....p.
 Fig. 6. *Spirifer*, sp. Top of section near Newark Div. III.....p.
 Fig. 7. *Spirifer deltoideus*, sp.n. Congl. I, Granville.....p. 2
 Fig. 8. *Spirifer bicipatus*. Newark, Div. III.....p.
 Fig. 9. *Spirifer striatiformis*, full grown dorsal valve. Newark, Div. III.-p.

PLATE III.

- Fig. 1. *Lingula* (*scotia* var.) *waverlyensis*, Her.....p.
 Fig. 2. *Lingula gannensis*, Her. Dorsal valve, *b. striæ* enlarged.....p.
 Fig. 3. *Lingula gannensis*, ventral valve.....p.
 Fig. 4. *Lingula membranacea*, Win ventral valve.....p.
 Fig. 5. *Orbiculoides pleurites*, Meek, ventral valve.....p.
 Fig. 6. *Athyris ashlandensis*, Her.....p.
 Fig. 7. *Syringothyris*, sp. view of the interior of beak.....p-
 Fig. 8-9. *Terebratulina inconstans*, Her.....p-
 Fig. 10. *Productus nodocostatus*. Upper Waverly.....p-
 Fig. 11. *Spirifer disjunctus*, H. Erie Shale, Peninsula, O.
 Fig. 12. *Grammysia ovata*, Her.....p-
 Fig. 13. *Martinia prematura*, H. Erie Shale.
 Fig. 14. Tooth of fish.
 Fig. 15. *Productus rushkillensis*, Her.....p-
 Fig. 16. *Leiorhynchus* ? *richlandensis*, Her.
 Fig. 17. *Productus (newberryi) var. annosus*, Her.....p-
 Fig. 18. *Rhynchonella marshallensis*, Win.....p-
 Fig. 19. *Productus varicostatus*, Her.....p-

PLATE IV.

- Fig. 1. *Sphenotus vatnulus*, 30 feet below congl. I.
 Fig. 2. *Prothyris meeki*, Gann. Div. II.
 Fig. 3. *Ctenodonta houghtoni* ? 30 feet below congl. I. Union Station ..p-
 Fig. 4. *Palaeonilo curta*. Freestone, Div. II.....p-
 Fig. 5. *Dexiohia ovata*. Near congl. II.....p-
 Fig. 6. *Oracardia cornuta*, sp. n. Lamellibranch layer below congl. I..p-
 Fig. 7. *Dexiohia ovata*, Gann.....p-
 Fig. 8. *Oracardia ornata*, sp n. Freestone, Granville.....p-
 Fig. 9. Hinge view of same specimen.

- Fig. 10. *Oracardia ornata*. Large specimen-----p. 43.
 Fig. 11. *Nuculana*, sp. Gann. near congl. II.
 Fig. 12. *Nuculana*, sp. Freestone, Granville.
 Fig. 13. *Nuculana similis*. Below congl. I.
 Fig. 14. *Palaeoneilo consimilis*. Shale 1 mile east of Harlam, O-----p. 43.
 Fig. 15. *Palaeoneilo ignota*. Moots run-----p. 44.
 Fig. 16. *Nuculana saccata*, ? Below congl. I.
 Fig. 17. *Palaeoneilo sulcatina*. 30 feet below congl. I.
 Fig. 18. *Palaeoneilo* ? *marshallensis*. Div. III, Rushville-----p. 43
 Fig. 19. *Macrodon newarkensis*. Div. III, Newark-----p. 36.
 Fig. 20. *Spathella ventricosa*. Freestone, Granville-----p. 31.
 Fig. 21. *Mytilarca fibristriata*. Moot's run-----p. 31.
 Fig. 22. *Nuculana diversa* ? Peninsula, O.
 Fig. 23. *Nuculana nuculaformis* ? Above conglomerate II, Newark----p. 45.

PLATE V.

- Fig. 1. *Edmondia sulcifera*. Right valve, Moot's run-----p. 30.
 Fig. 2. Hinge view of smaller valve of same species.
 Fig. 3. *Crenipecten cancellatus*. Moot's run-----p. 34.
 Fig. 4. *Leiopteria* (*Leptodesma*) *ortoni*, largest specimen yet collected, 40 feet below conglomerate I.
 Fig. 5. *Leiopteria*, sp. Freestone.
 Fig. 6. *Leptodesma scutella*. Freestone, (Cf. vol. iii, Plate IV)-----p. 30.
 Fig. 7. *Conocardium* (Cf. *alternistriatum*). Moot's run-----p. 40.
 Fig. 8. *Leiopteria*, sp. Freestone.
 Fig. 9. *Crenipecten caroli*, ? Gann. freestone.
 Fig. 10. *Streblopteria*, Gann. Freestone.
 Fig. 11. *Avicula* (?) *subspatulata*, sp. n. Div. III, Newark-----p. 20.
 Fig. 12. *Pterinopecten cariniferus*, peculiarly modified left valve-----p. 33.
 Fig. 13. *Pterinopecten letus* H. Moot's run.
 Fig. 14. *Crenipecten crenistriatus*. Div. III, Newark-----p. 34.
 Fig. 15. *Streblopteria*, sp. Div. III, Newark.
 Fig. 16. Crinoid arm, Sciotoville.

PLATE VI.

- Fig. 1. *Schizodus prolongatus*, Her. Lamellibranch layer-----p. 36.
 Fig. 2. *Schizodus palaeoneiliformis*. Freestone.
 Fig. 3. *Schizodus harlamensis*. 1 mile east of Harlam.
 Fig. 4. *Sphenotus* (*Cypriocardia*). Lamellibranch layer.
 Fig. 5. *Grammysia famelica*, Her.-----p. 35.
 Fig. 6. *Schizodus newarkensis*, Her. Tank, Newark-----p. 36.

- Fig. 7. *Macrodon*, sp. Moot's run.
 Fig. 8. *Cypricardina scitula*, Her. Moot's run.-----
 Fig. 9. *Macrodon reservatus*. Freestone.
 Fig. 10. *Schizodus triangularis*, Her. Freestone.-----
 Fig. 11. *Grammysia* (?) *hannibalensis*, Shum. Freestone.
 Fig. 12. *Schizodus quadrangularis*, H. Freestone.
 Fig. 13. *Schizodus triangularis*, Her. Freestone.-----
 ("Macrodon ?? triangularis," of vol. iii.)

PLATE VII.

- Fig. 1. *Orthoceras rushensis* ? 30 feet below congl. I.
 Fig. 2. *Goniatites lyoni*. Freestone.
 Fig. 3. *Nautilus*. Moot's run.
 Fig. 4. Moot's run.
 Fig. 5. *Euomphalus latus*. Freestone.
 Fig. 6. *Murchisonia*, sp. Moot's run.
 Fig. 7. *Loxonema*, sp. Tank, Newark.
 Fig. 8. *Nautilus*, sp. Tank, Newark.
 Fig. 9. *Pleurotomaria strigillata*. Freestone.
 Fig. 10. *Pleurotomaria (Flemingia) stulta*, Her. Freestone.-----
 Fig. 11. *Pleurotomaria vadosa*, Win. ? 1 mile east Harlam.
 Fig. 12. *Platyceras vomerum*, Win. ? Moot's run,

PLATE VIII.

- Fig. 1. *Platyceras lodiensis*, var. ? Bagdad, O.-----
 Fig. 2. *Conularia gracilis*, Her. 2a, the smallest specimen seen; 2b, largest specimen seen, restored; 2c, camera drawing of a portion of the surface greatly magnified.-----
 Fig. 3. *Conularia victa*, White.
 Fig. 4. *Conularia micronema*, Meek. 4a, camera drawing of surface n
 Fig. 5. *Conularia newberryi*. Camera drawing of surface magnified.
 Fig. 6. *Zaphrentis* (?). Upper layers at Rushville.
 Fig. 7. *Platyceras lodiensis*, ? Ashland Co.
 Fig. 9. *Cythere ohioensis*, Her. Upper layers at Rushville.-----

PLATE IX.

Fossils from Bedford shales at Central College.

- Fig. 1. *Lingula melie*.
 Fig. 2. *Discina*, sp.
 Fig. 3. *Martinia umbonata*.

- Fig. 4. *Macrodon hamiltonæ*, H.
 Fig. 5. *Goniatites*, sp.
 Fig. 6. *Strophomena rhomboidalis*. From shales above Berea grit.
 Fig. 7. *Atrypa reticularis*. From shales above Berea grit.
 Fig. 8. *Palzoneilo bedfordensis*, Meek.
 Fig. 9. *Microdon bellistriatus*.
 Fig. 10. *Orthis vanuxemi*?
 Fig. 11. *Bellerophon helena*?
 Fig. 12. *Pterinopecten*, sp.
 Fig. 13. *Nuculana diversa*, H.
 Fig. 14. *Pleurotomaria sulcomarginata*?
 Fig. 15. *Loxonema delphicola*?
 Fig. 16. *Orthoceras*, sp.

PLATE X.

- Fig. 1. *Solenomya*? *cuyahogensis*, sp. n. p. 115.
 Fig. 2. *Palzoneilo*, sp.
 Fig. 3. *Edmondia*, sp.
 Fig. 4. *Nucula houghtoni*?
 Figs. 5, 6, 7. *Entolium aviculatum*.
 Figs. 8-9. *Cremipecten*, sp.
 Fig. 10. *Aviculopecten*, sp.
 Fig. 11. *Aviculopecten*, sp.
 Fig. 12. *Aviculopecten*, sp.
 Fig. 13. *Avicula recta*, sp. n. p. 115.
 Fig. 14. *Platyceras*, sp.
 Fig. 15. *Macrodon* (allied to) *tenuistriata*.
 Fig. 16. *Palzoneilo*, sp.
 Figs. 17-18. *Spirifer biplicatus*.
 Fig. 19. *Spirifer*, sp.
 Fig. 20. *Spirifer hirtus*.
 Figs. 21-22. *Orthis*, sp.
 Fig. 23. *Atrypa*, sp.
 Fig. 24. *Productus newberryi* p. 20.
 Fig. 25. *Hemipronites*.
 Fig. 26. *Chonetes*, sp.
 Fig. 27. *Conularia newberryi*.
 Fig. 28. Surface characters of an associated species of *Conularia*.

The above figures are intended to illustrate the nature of the fauna at the highest horizon of the Waverly, at Cuyahoga Falls, only 30 feet below the carboniferous conglomerate. These species have not been elaborated because it is hoped that Prof. Clappole of Akron, will soon give this region a careful study.

- Fig. 29. *Lingula cuyahoga*, Hall.
 Fig. 30. *Lingula atra*, sp. n. p. 16.
 Fig. 31. *Lingula meeki*, sp. n. p. 18.
 Fig. 32. *Lingula melie*, H. ?

- Fig. 33. *Orbiculoides newberryi*, H.-----p. 12.
 Fig. 34. *Allorisma cuyahoga*, sp. n.-----p. 28.
 Fig. 35. *Productus*, sp.
 The above are from a horizon about 100 feet lower in Cuyahoga valley.
 Fig. 36. *Fenestella albida*. var. ?
 Fig. 37. *Pinnatopora intermedia*, Ulrich.
 Fig. 38. *Pleurotomaria*, sp.
 Fig. 39. *Rhynchonella*, sp. These from Cuyahoga Falls.
 Fig. 40. *Chonetes*, sp. About 160 feet below conglomerate
 Fig. 41. *Pleurotomaria stella*, Win. Shale over congl. II.
 Fig. 42. *Orbiculoides pleurites*, M. Shale over congl. II.
 Fig. 43. *Cypriocardinia* ? sp. Highest horizon at Rushville.
 Fig. 44. *Conocardium*, sp. Highest horizon at Rushville.

PLATE XI.

[Forms plate of same number in vol. iii.]

- Fig. 1. *Mytilarca occidentalis*, White ? -----p. 32,
 Fig. 2. *Platyceras lodiensis*, Meek.
 Fig. 3. *(Phillipsia meramecensis* For this figure see Plate I, fig. 6.)
 Fig. 4. *Pterinopecten ashlandensis*, Her.-----p. 33,
 Fig. 5. *Lyriopecten nodocostatus*, Her.-----p. 32.
 Fig. 6. *Macrocheilus ponderosus*. Coal measures.
 Fig. 7. *Macrocheilus fusiformis*. Coal measures.
 Fig. 8. *Naticopsis nama*. Coal measures.
 Fig. 9. *Naticopsis nodosa*. Coal measures.
 Fig. 10. *Macrocheilus paludineformis*. Coal measures.
 The above from Fultonham, just above the Chester.
 Fig. 11. *Productus parvus*. Chester limestone.
 Fig. 12. *Allorisma andrewsi*. Chester limestone.
 Fig. 13. *Allorisma consanguinatus*. Her. Shale over congl. II.
 Fig. 14. *Spirifer increbescens* Chester limestone,
 Fig. 15. *Spirifer glaber*. Chester limestone.
 Fig. 16. *Nautilus bisulcatus*, Her. Chester limestone.
 Fig. 17. *Lophophyllum*, sp. Chester limestone.
 Fig. 18. *Terebratulina inconstans*, Her. Waverly -----p. 24.
 Fig. 19.
 Fig. 20. *Cyrtina acutirostris*, Shum. Lodi, O.
 Fig. 21. *Rhynchonella contracta*. Bagdad, O.-----p. 23.
 Fig. 22. *Rhynchonella marshallensis*, ? Lodi, O.-----p. 23.
 Fig. 23. *Spirifer increbescens*. From limestone fragments in coal measure conglomerate in Licking Co.
 Fig. 24. *Conocardium alternistriatum*, Her.-----p. 42.
 Fig. 25. *Crenipecten cancellatus*, Her.-----p. 34

- Figs. 26,29. *Productus duplicostatus*, Win. Distorted dorsal and perfect
ventral valve.....p. 21.
Fig. 27. *Macrodon striatocostatus*, Herp. 21.
Fig. 28. *Macrodon*. sp. Portsmouth.
Fig. 30. *Leopleria nasutus*, Her. Bagdad.....p. 29.

TABULATED LIST OF FOSSILS

KNOWN TO OCCUR IN THE WAVERLY OF OHIO.

Compiled by W. F. COOPER.

The following list is designed to display at a glance the vertical position of all species reported from the Waverly group. While it is attempted to include all species reported in Ohio, it has not been possible to entirely eliminate synonymy and it is probable that some species have been overlooked.

Those species which have not been seen by us are indicated by an initial indicating, not the authority for the name, but the person upon whose observation the presence of the form in Ohio rests. Thus [W.] indicates Prof. Alex. Winchell, [H.] Prof. James Hall, [M.] Mr. F. B. Meek and [N.] Prof. J. S. Newberry.

The sub-divisions in the table are artificial, but correspond in a general way with the horizons and sub-divisions indicated in Prof. Herrick's papers. They are as follows: I, all below conglomerate I. I₁, Bedford shale, I₂, Berea grit, I₃, lower part of Berea shale, I₄, upper part of Berea shale (about 150 feet, up to within 40-60 feet below conglomerate I.) I₅, Waverly shale (40 feet below congl. I.) II, Kinderhook division, II₁, freestone of central Ohio, II₂, shale below congl. II. III, Upper or Logan division, III₁, shale over conglomerate II, III₂ freestone and shale up to about 100 feet above congl. II, (Burlington), III₃, upper layers (Keokuk) about 25 feet.

Additions and corrections to the list are solicited.

NAME.	Division I					Div II		Div III		
	1	2	3	4	5	1	2	1	2	3
PISCES.										
<i>Cladodus pattersoni</i> , [N.]				?						
<i>Ctenacanthus formosus</i> , [N.]										?
<i>Gyracanthus alleni</i> , [N.]										?
" <i>compressus</i> , [N.]										?
<i>Orodus variabilis</i> , [W.]				?						
<i>Palæoniscus brainardi</i> , [N.]		o								
CRUSTACEA.										
<i>Cythere ohioensis</i> .										o
" <i>crassimarginata</i> , [W.]										?
<i>Phaethonides occidentalis</i> .							o			
" <i>spinosus</i> .					o					
" ? <i>immaturus</i> .					o					o
" ? <i>lodiensis</i> .				?						
<i>Phillipsia meramecensis</i> .										o
" <i>serraticaudata</i> .										o
" ? <i>consors</i>										
" (<i>Proetus</i>) <i>auriculatus</i> ,					o		o			
<i>Proetus minutus</i> .					o					
" <i>doris</i> , [W.]					o					
" <i>præcursor</i> .										
LAMELLIBRANCHATA.										
<i>Allorisma nobilis</i> .							o			
" <i>cooperi</i> .							o			
" <i>winchelli</i> .										o
" <i>ventricosa</i>										o
" <i>convexa</i> .										o
" <i>cuyahoga</i> .										o
" <i>consanguinatus</i> .										o
<i>Arca ornata</i> .					o					
<i>Arca modesta</i> , [W.]										
<i>Avicula</i> (<i>Leptodesma</i>) <i>scutella</i> .							o			
" ? <i>sub-spatulata</i> .										o
<i>Aviculopecten perelongatus</i> .							o			
" <i>cooperi</i> .					o					
" <i>oweni</i> .							?			
" <i>whitei</i> , [W.]										
" <i>newarkensis</i> .										
" <i>occidentalis</i> , [W.]										
" <i>tenuicostatus</i> , [W.]										
<i>Cardiopsis</i> (<i>Dexiobia</i>) <i>ovata</i> .							o			
<i>Conocardium pulchellum</i> .							o			
" <i>alternistriatum</i>										?
<i>Crenipecten granvillensis</i> .										o
" <i>subcardiformis</i> .					o					
" <i>senilis</i> ?							?			
" <i>crenistriatus</i> .										o
" <i>cancellatus</i> .					o					
<i>Ctenodonta iowensis</i>					o					
" <i>stella</i> .					o					
" <i>houghtoni</i> .							?			o

NAME.	Division I					Div II		Div III		
	1	2	3	4	5	1	2	1	2	3
<i>Ctenodonta sectoralis</i> , [W.]										
<i>Cypricardinia</i> (<i>Microdon</i>) <i>scitula</i> .					o					
<i>Edmondia depressa</i> .							o			
“ <i>burlingtonensis</i> .							o			
“ <i>sulcifera</i> .					o					
“ <i>aequimargintus</i> , [W.]										
<i>Grammysia</i> <i>ovata</i> .										o
“ <i>famelica</i> .							o			
“ <i>rhomboides</i> .										
“ <i>ventricosa</i> .								o		
“ <i>hannibalensis</i> .									o	o
<i>Leiopteria</i> <i>ortoni</i> .					o					
“ <i>halli</i> .							o			
“ <i>sp.</i>					o					
“ <i>sp.</i>							o			
“ <i>nasutus</i> .					o					
“ <i>newberryi</i> .										o
<i>Leptodesma</i> <i>scutella</i> .							o			
<i>Limatulina</i> <i>ohioensis</i> .										o
<i>Lyriopecten</i> ? <i>cancellatus</i> .							o			
“ <i>nodocostatus</i> .										
<i>Macrodon</i> <i>newarkensis</i> .							o			
“ <i>striato-costatus</i> .										o
“ <i>sp.</i>							o			
<i>Microdon</i> <i>reservatus</i> .								o		
<i>Modiola</i> <i>waverliensis</i> .								o		
<i>Modiomorpha</i> <i>hyalea</i> .								o		
<i>Myalina</i> <i>michiganensis</i> .								o		
<i>Mytilarca</i> <i>fibristriatus</i> .							o			
“ <i>occidental</i> .										?
<i>Nuculana</i> <i>spatulata</i> .								o		
“ <i>similis</i> .								o		
“ <i>var.</i>								o		
“ <i>sp.</i>								o		
“ <i>sp.</i>								o		
“ <i>nuculaeformis</i> ?										
“ <i>barrisi</i> , [W.]									o	
<i>Oracardia</i> <i>cornuta</i> .								o		
“ <i>ornata</i> .								o		
<i>Ortho</i> <i>nota</i> <i>rectidorsalis</i> .								o		
<i>Palaeoneilo</i> <i>elliptica</i> .								o		
“ <i>plicatella</i> .								o		
“ <i>elegantula</i> .								o		
“ <i>marshallensis</i> .							o	o	o	?
“ <i>allorismiformis</i> .								o		
“ <i>attenuata</i> .								o		
“ ? <i>ohioensis</i> .							o			
“ <i>consimilis</i> .							o			
“ <i>ignota</i> .								o		
“ (<i>Nucula</i>) <i>curta</i> .								o		
“ <i>sulcatina</i> .								o		
<i>Pholadella</i> <i>newberryi</i> .								o	o	

[illegible]



BARNES

PATENT

Foot-Power
Machinery

FOR THE ACTUAL

Business of the Workshop

Outfits complete,
for Schools of In-
dustrial Training.
With them a prac-
tical Journeyman's
Trade, in wood or
metal, can be ac-
quired. Illustrated
catalogue free.

Address,



W. F. & JOHN BARNES CO.,

479 RUDY STREET,

ROCKFORD, ILL.

[illegible]

MISCELLANEOUS NOTES.

A NOTE ON A PECULIAR HABIT OF FRESH WATER HYDRA.

During the last of September, while examining, in the laboratory, an aquarium containing Hydrodictyon, Spirogyra and other plants, I noticed on the sides of the aquarium a few Hydras and, as the class in Zoology would need some for study about the last of November, I placed the vessel in a window and renewed the water from time to time and soon noticed that the Hydras were reproducing by budding very rapidly. As the time approached for the class to need them, there was quite a large number, with buds in all stages of development.

But, greatly to my surprise, in a day or two afterwards, when I went to the aquarium to get specimens for the class, there was not a single Hydra to be seen on the sides of the aquarium, where they had been so abundant. My first thought was that some one had disturbed them, but upon accidentally turning over a piece of bark that happened to be in the bottom of the glass, I found underneath it all the animals that had but two days before been attached to the sides of the receptacle.

Upon examination, I found that, without exception, they were all reproducing by means of eggs. The large ovaries, and testes, producing spermatozoa with two flagella, forming from the ectoderm in numbers as high as six on a single animal. By placing some of these animals in the light they again began reproducing by budding. Thus showing by a few simple experiments that the most common method of reproduction, by budding, takes place in the light, but when the animal reproduces by means of eggs it seeks the dark and becomes quite inactive. A fall in the temperature of the room might account for the sudden change observed, in this case, in the method of reproduction. The eggs, covered with a thick chitinous shell, falling to the bottom, pass the cold months in that state. Both forms of Hydra vulgaris, H. viridis and the one under consideration, H. fusca, are quite common in this locality.

A more extended discussion of the Hydra may appear in a future issue of the Bulletin.

W. G. TIGHT.

LIST OF ALGÆ FROM GRANVILLE, O.

The following list adds a number of species to that given by Mr. H. L. Jones in volume II.

1. *Spirogyra dubia*.
2. *Spirogyra adnata*.
3. *Spirogyra fluviatilis*.
4. *Spirogyra* sp. (see below.)
5. *Zygnema cruciatum*.
6. *Zygnema stellatum* (*genuinum*.)
7. *Oedogonium fragile*.
8. *Oedogonium polymorphum*.
9. *Chaetophora fusiformis*.

10. *Conferva rhyphophila*. This plant grows in troughs and deep pools and stands perpendicular in great green masses resembling pillars. The stems are very fine threads and much crowded together.

11. *Oscillaria tenuis*.
12. *Oscillaria*.
13. *Hyalotheca mucosa*.
14. *Closterium acerosum*.
15. *Miscrasterias truncata*.
16. *Nostoc rupestre*.

17.. *Wolfia columbiana*. (Not properly included in a list of algæ, but mentioned on account of its association.)

Numbers 1, 2, and 12 of the above list were found in a pond fed by a spring and had their filaments commingled. In like manner, 5, 6, 7, 9, and 16 were closely associated. The nostoc was very sticky, so that the stems of the other plants, spores, and debris clung to masses of it. When the spores developed, the stems would grow all about among the Nostoc fronds.

The *Spirogyra* numbered 4, appears to be undescribed. Should this prove to be the case I would wish to call it

Spirogyra herricki sp. n.

Diameter about 3 m.; cells $2\frac{1}{2}$ to 4 times as long as broad; spirals 3, making $1\frac{1}{2}$ to a little more than 2 turns; cells not folded or replicate at the ends; spirals rather narrow, light green; fertile cells swollen; spore 42 m. by 22 m.

CHAS. L. PAYNE.

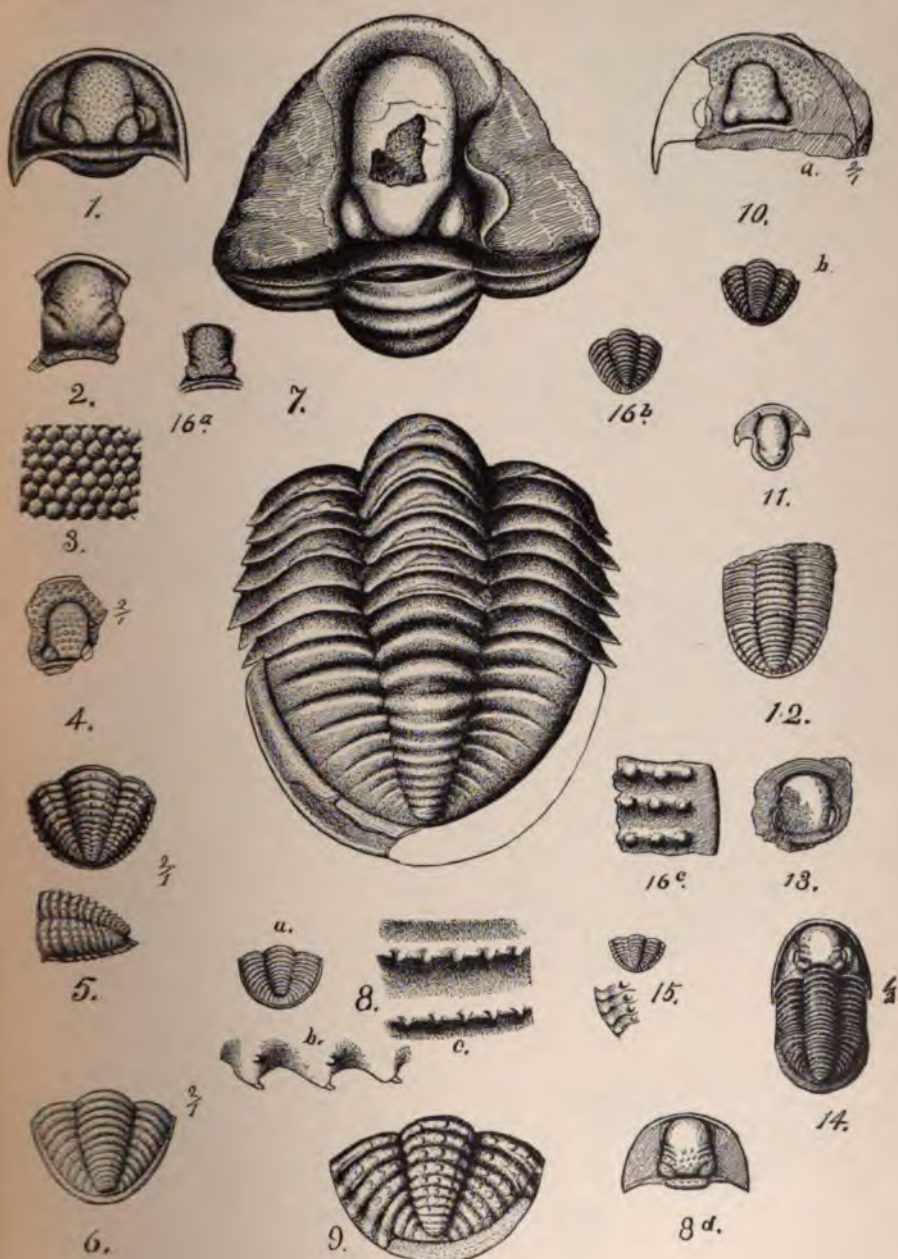
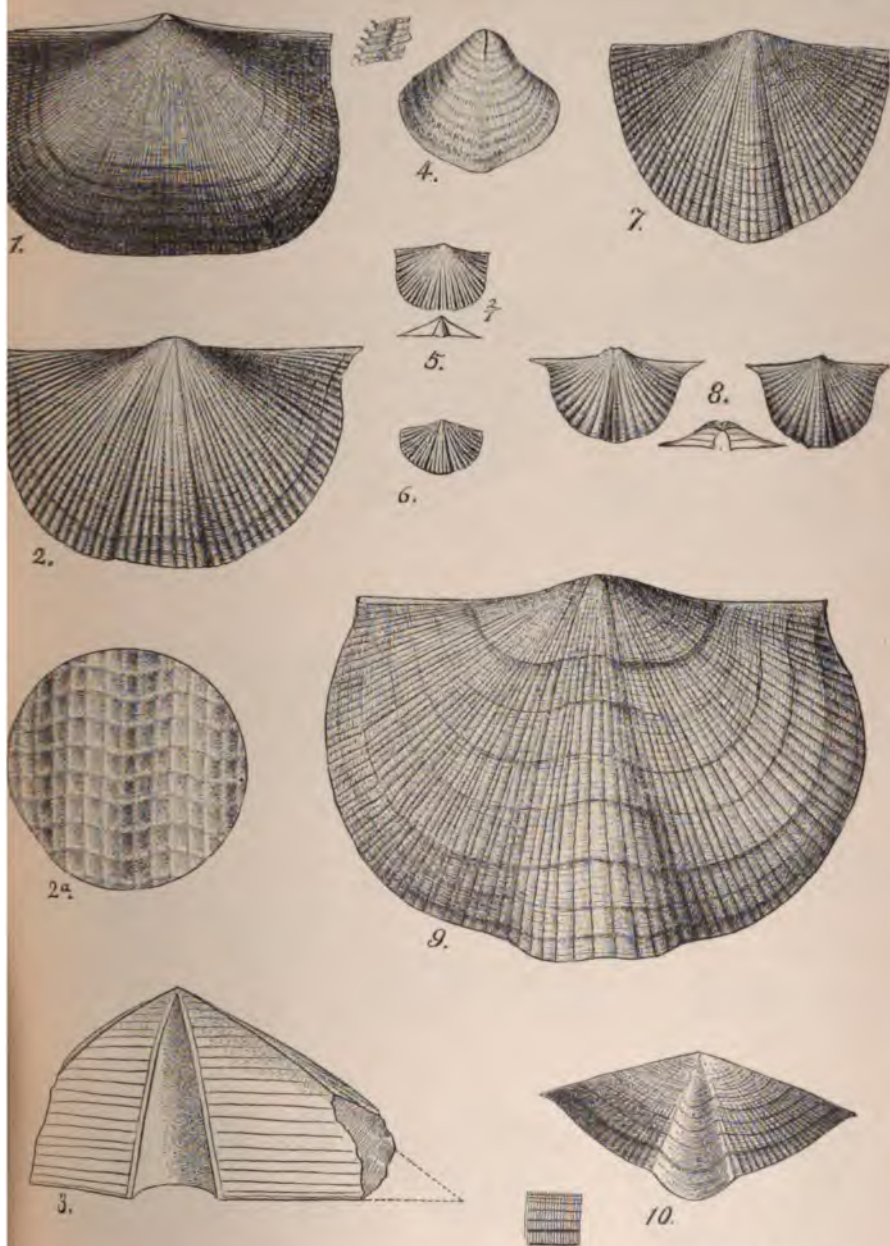


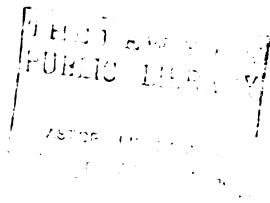
PLATE I.





C. L. Harris

PLATE II.



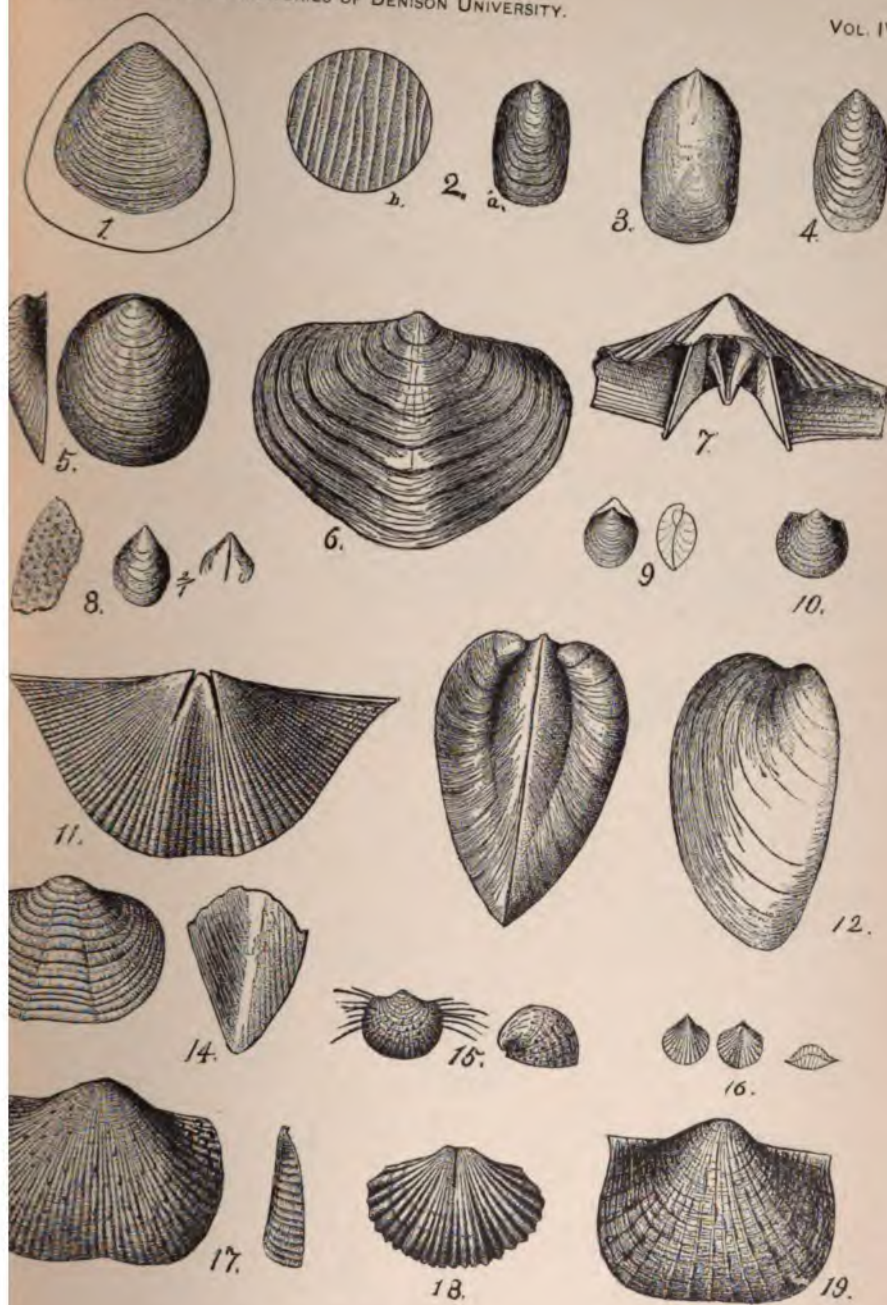


PLATE III.

THE NEW YORK
PUBLIC LIBRARY

ASTOR, LENOX AND
TILDEN FOUNDATIONS.

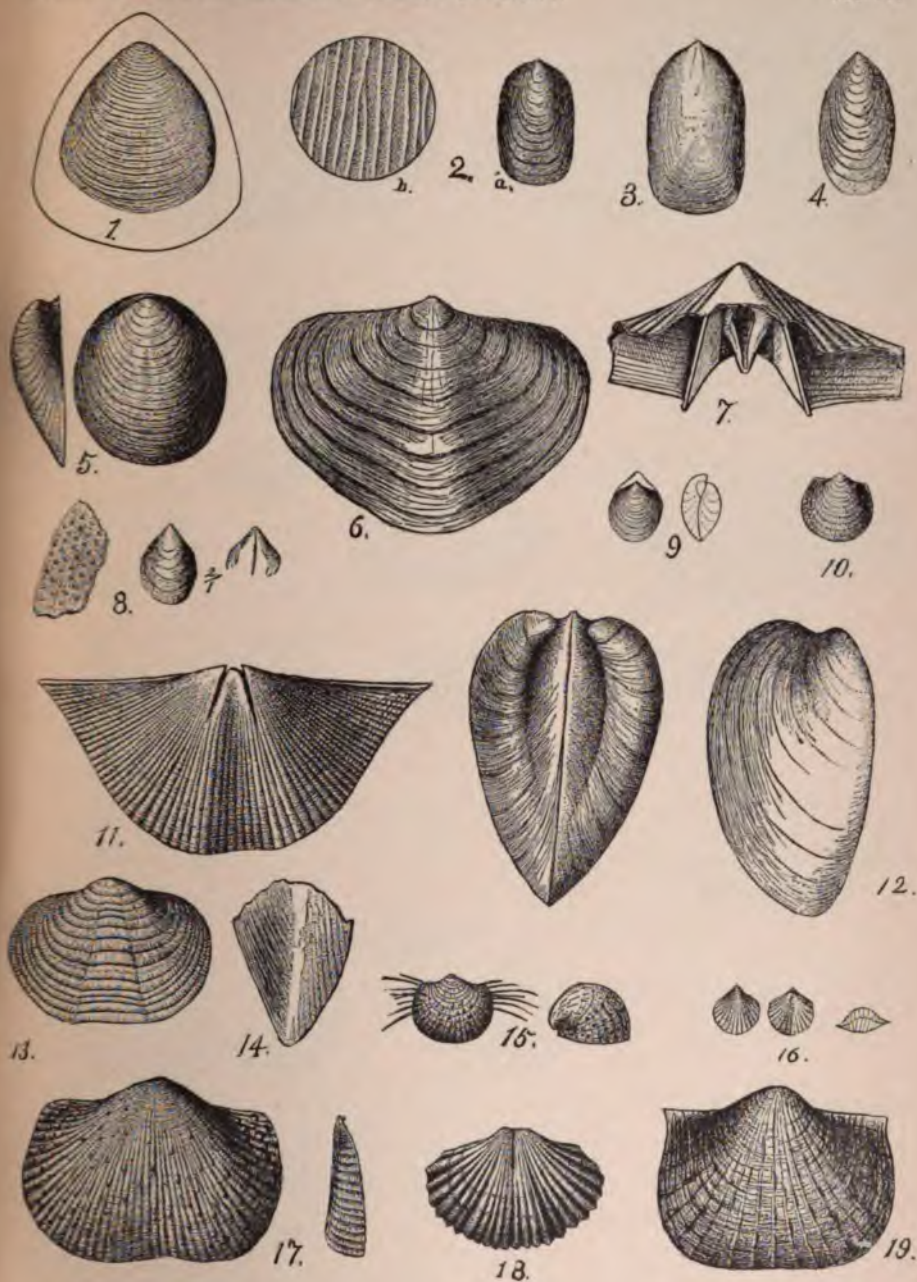
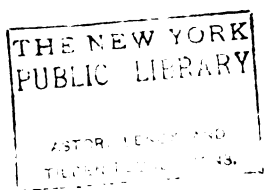


PLATE III.



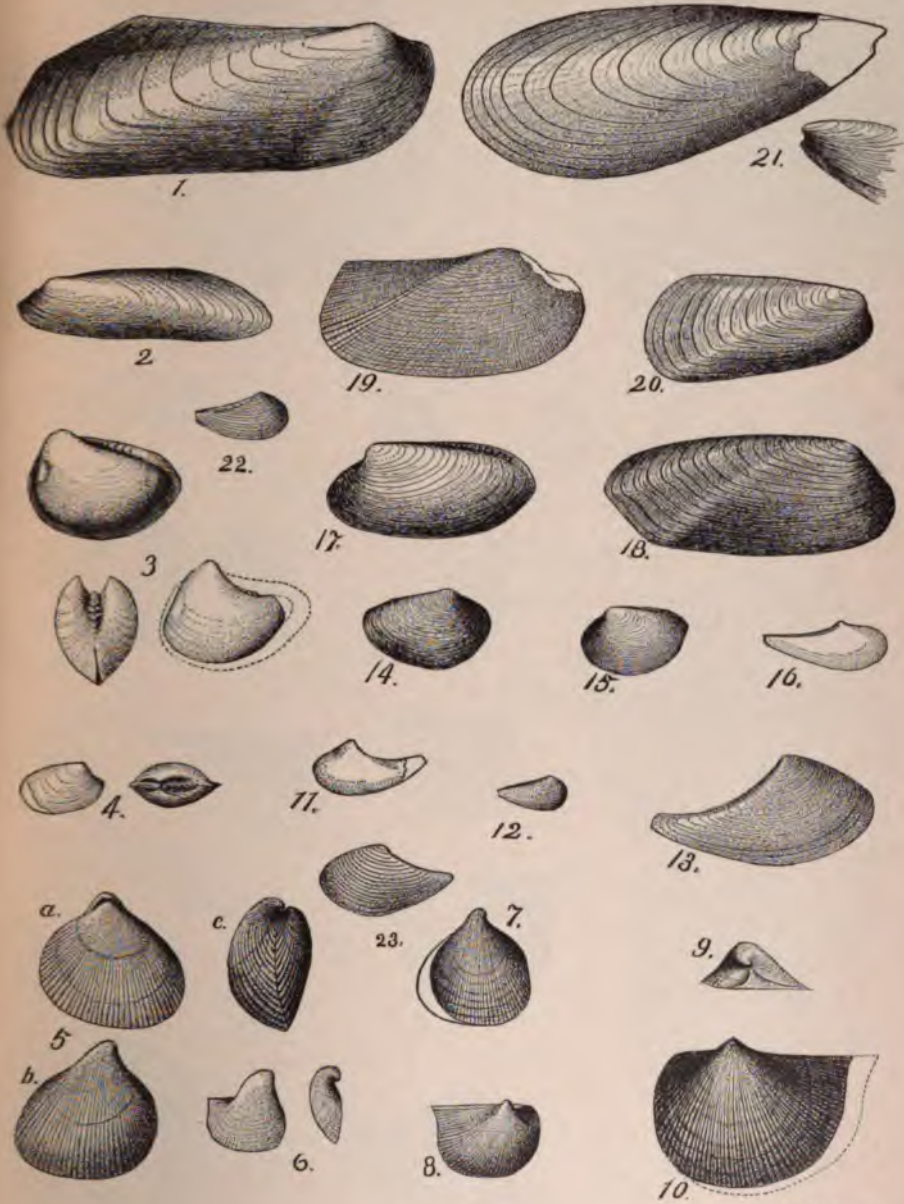


PLATE IV.

C.L. Merriam

THE NEW YORK
PUBLIC LIBRARY
ASTOR, LENOX AND
TILDEN FOUNDATIONS.

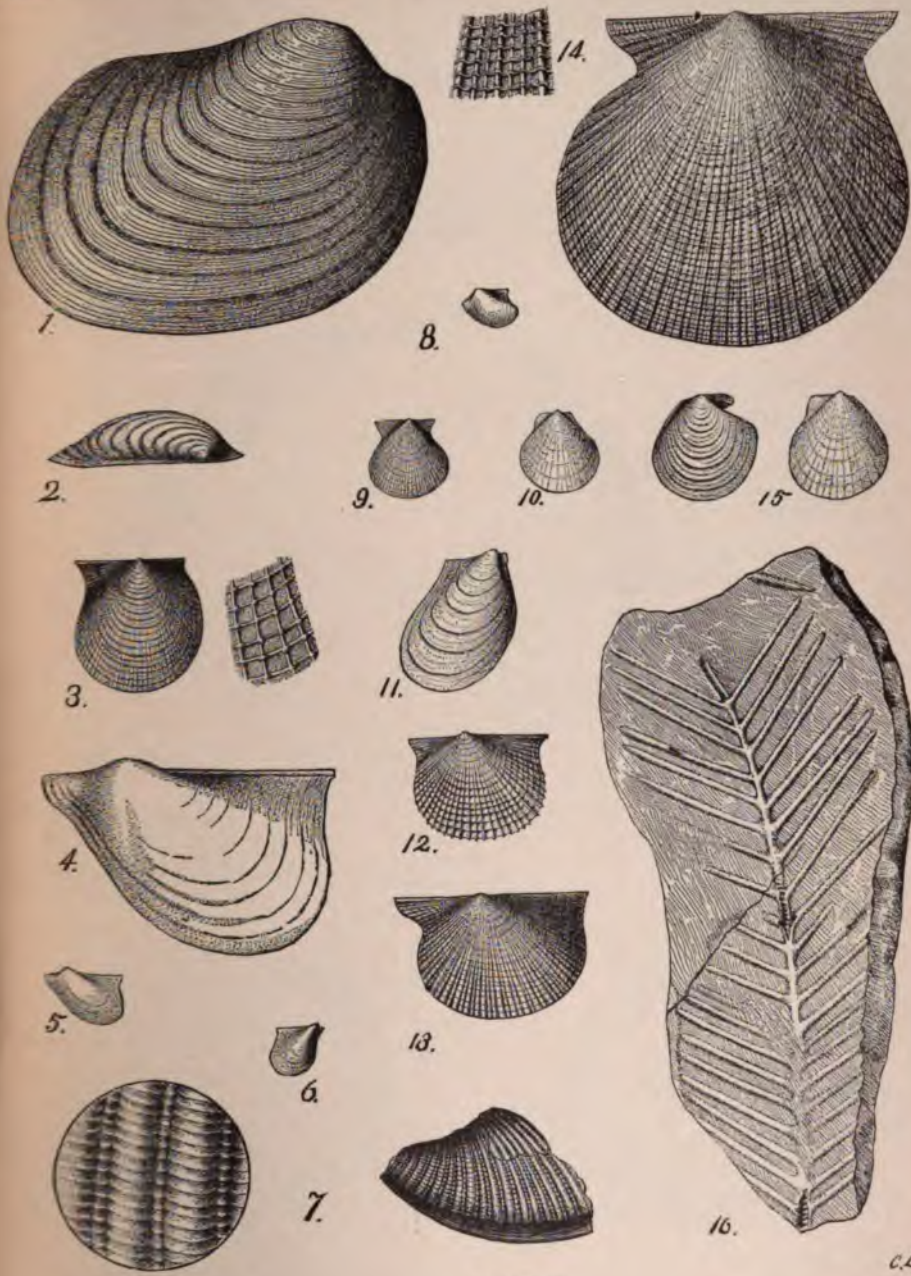


PLATE V.

C.L.H.

THE NEW YORK
PUBLIC LIBRARY
ASTOR, LENOX AND
TILDEN FOUNDATIONS.

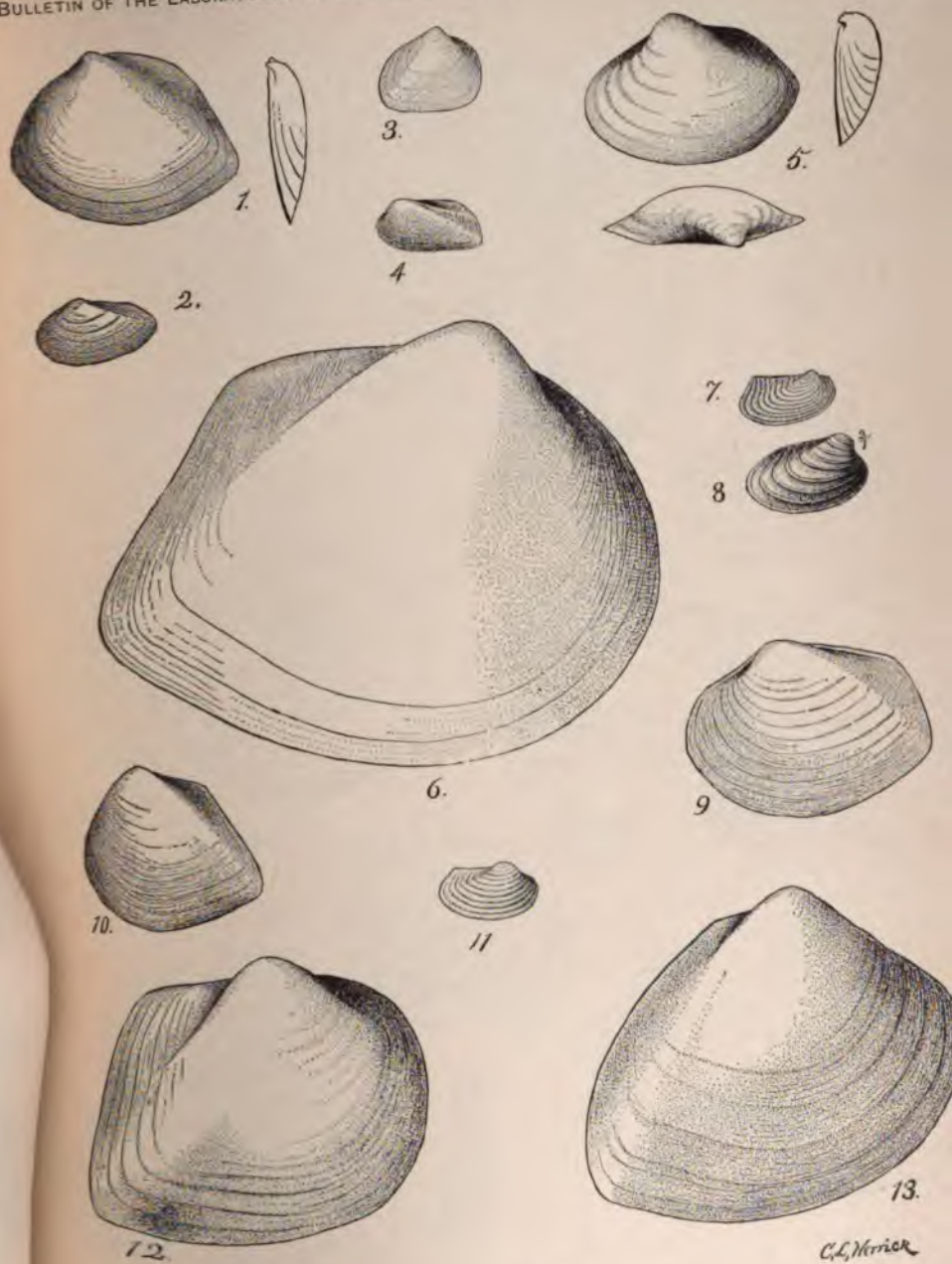
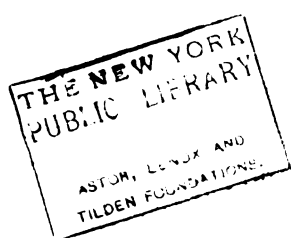
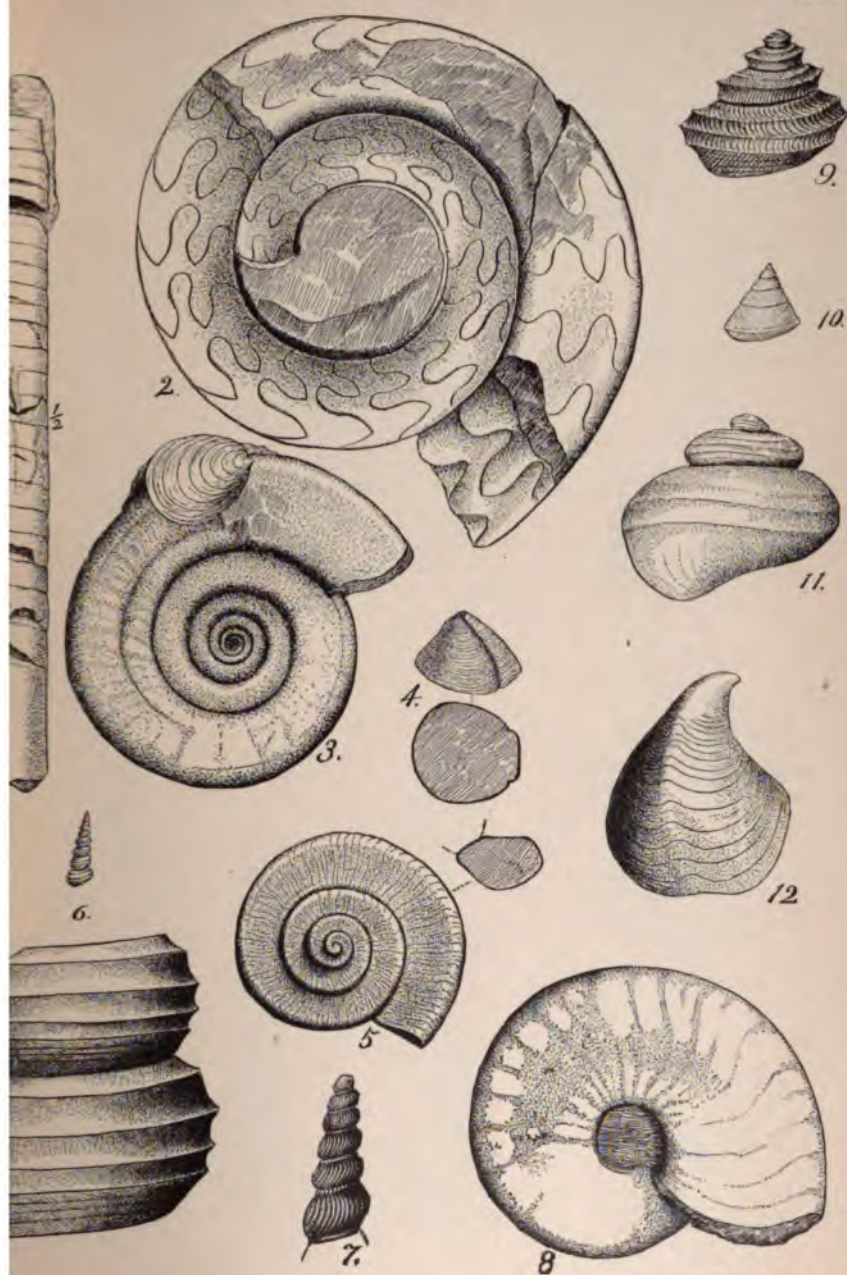


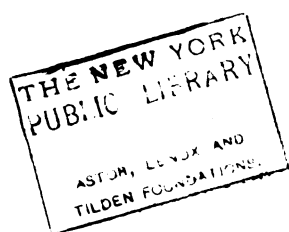
PLATE VI.





C. L. Herrick.

PLATE VII.



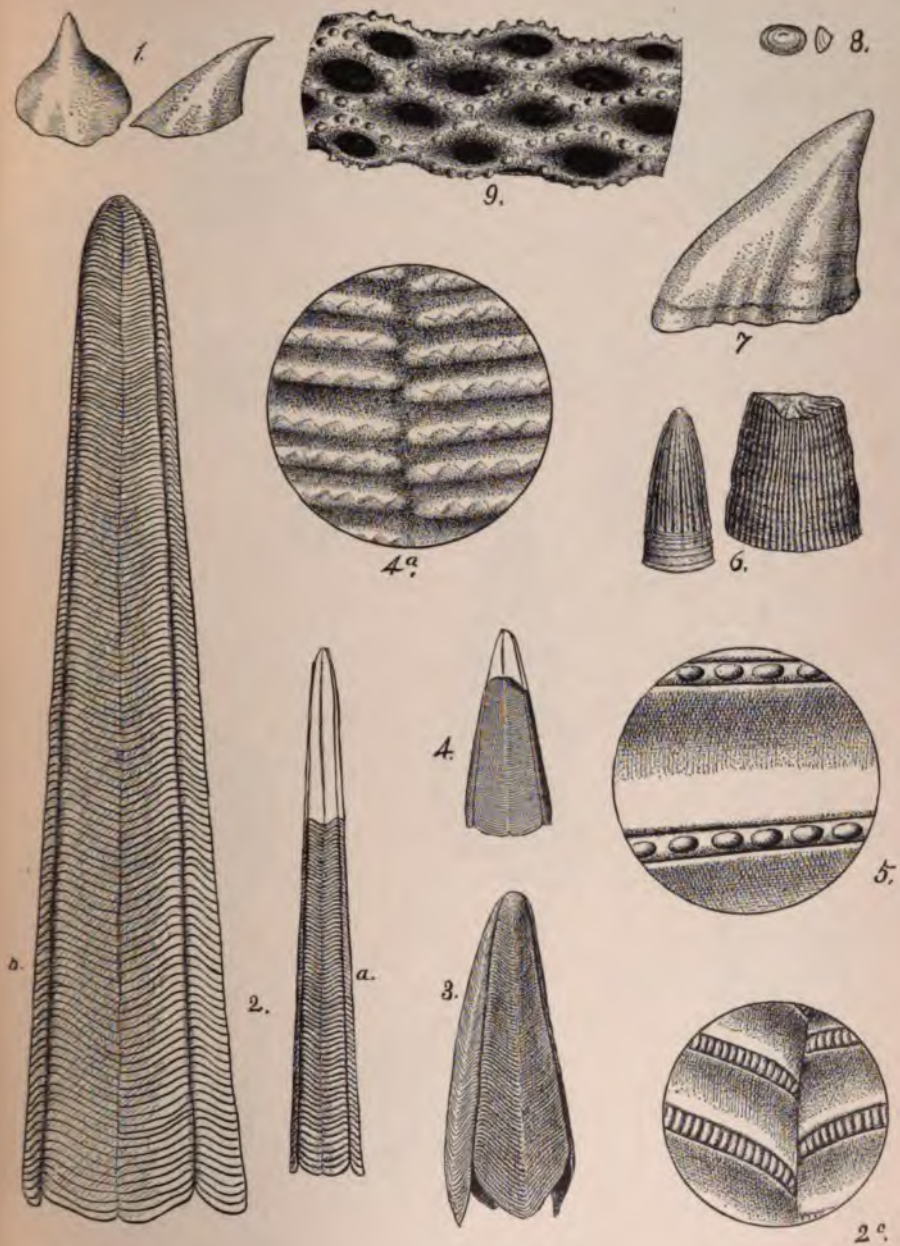


PLATE VIII.



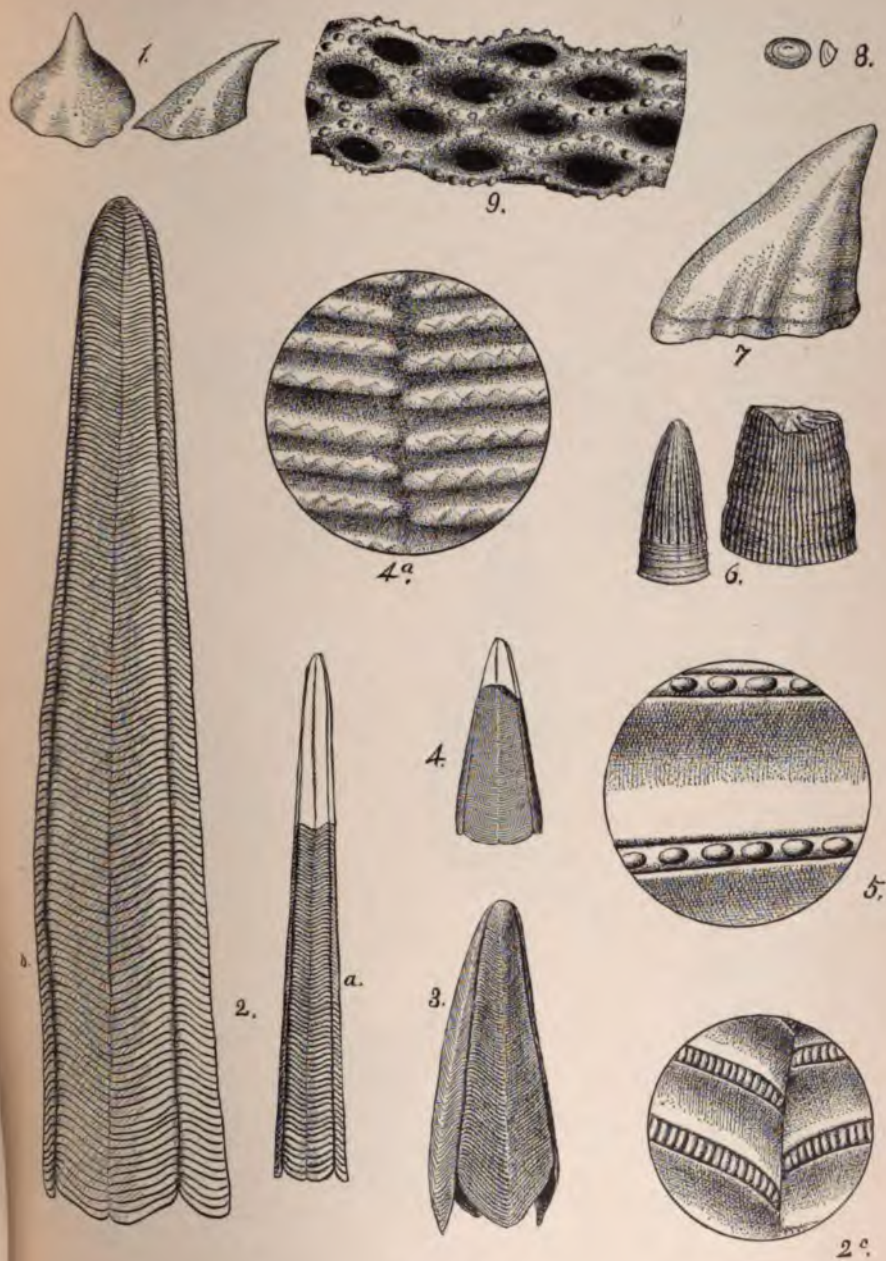


PLATE VIII.



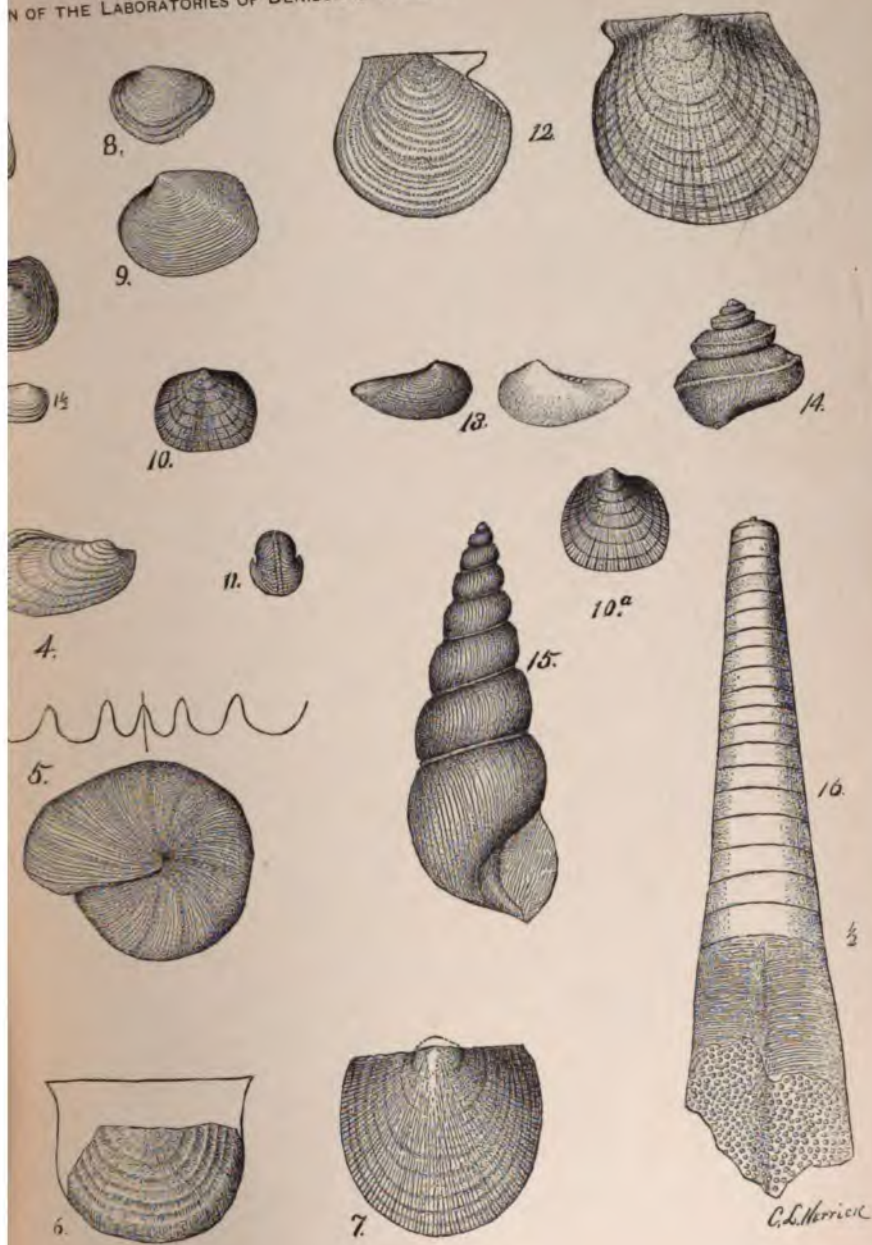


PLATE IX.



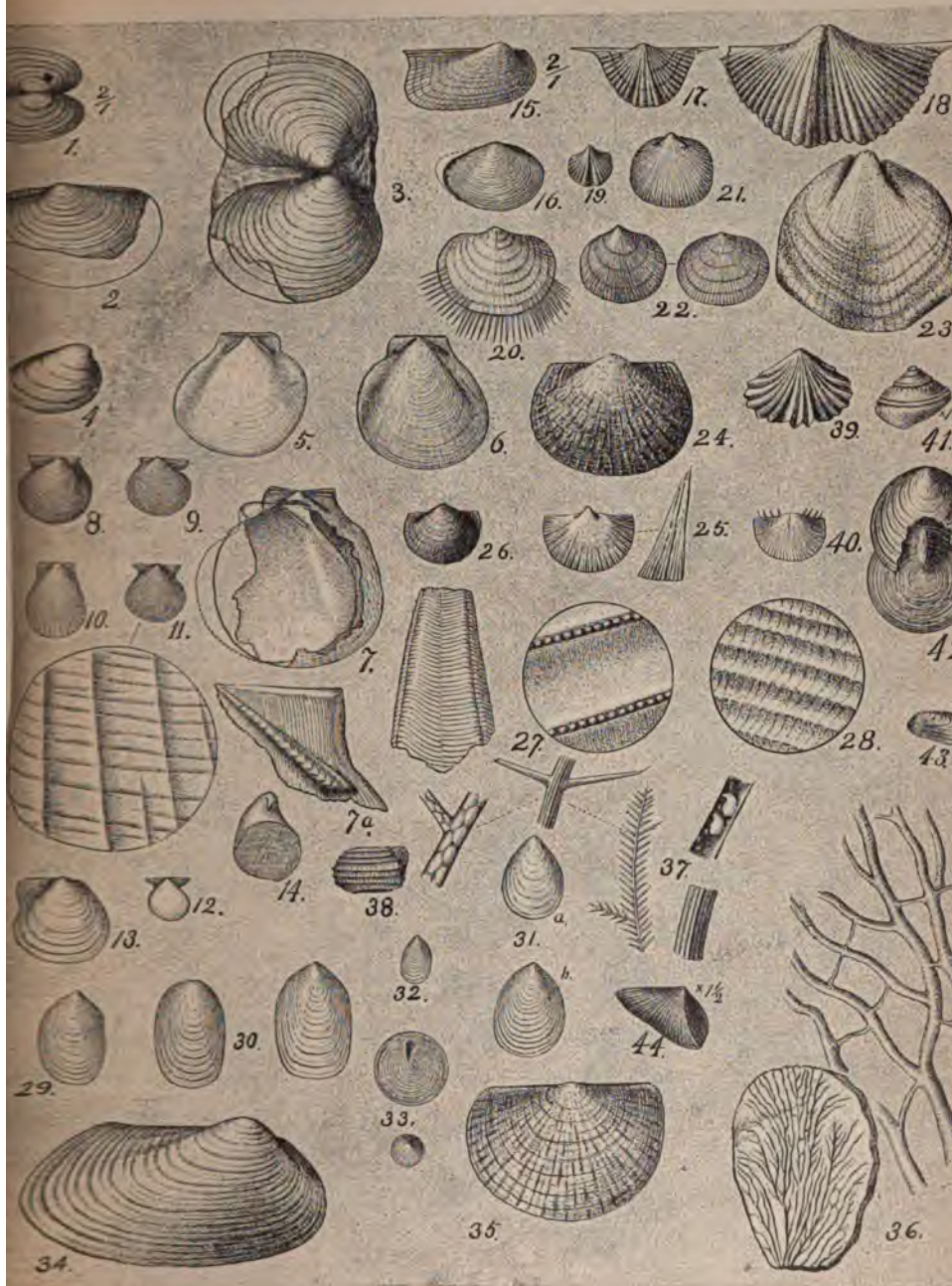


PLATE X.

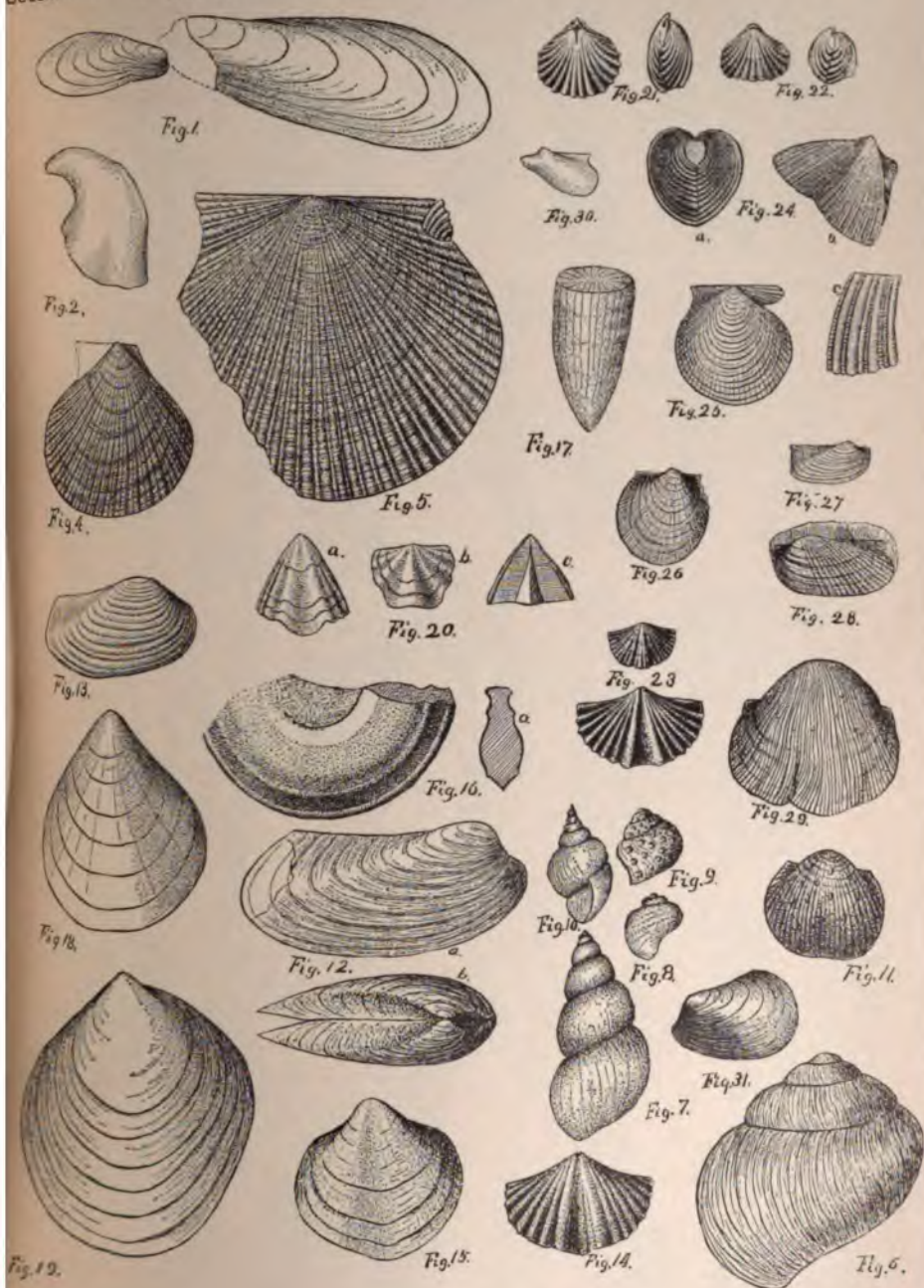
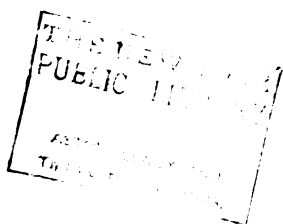
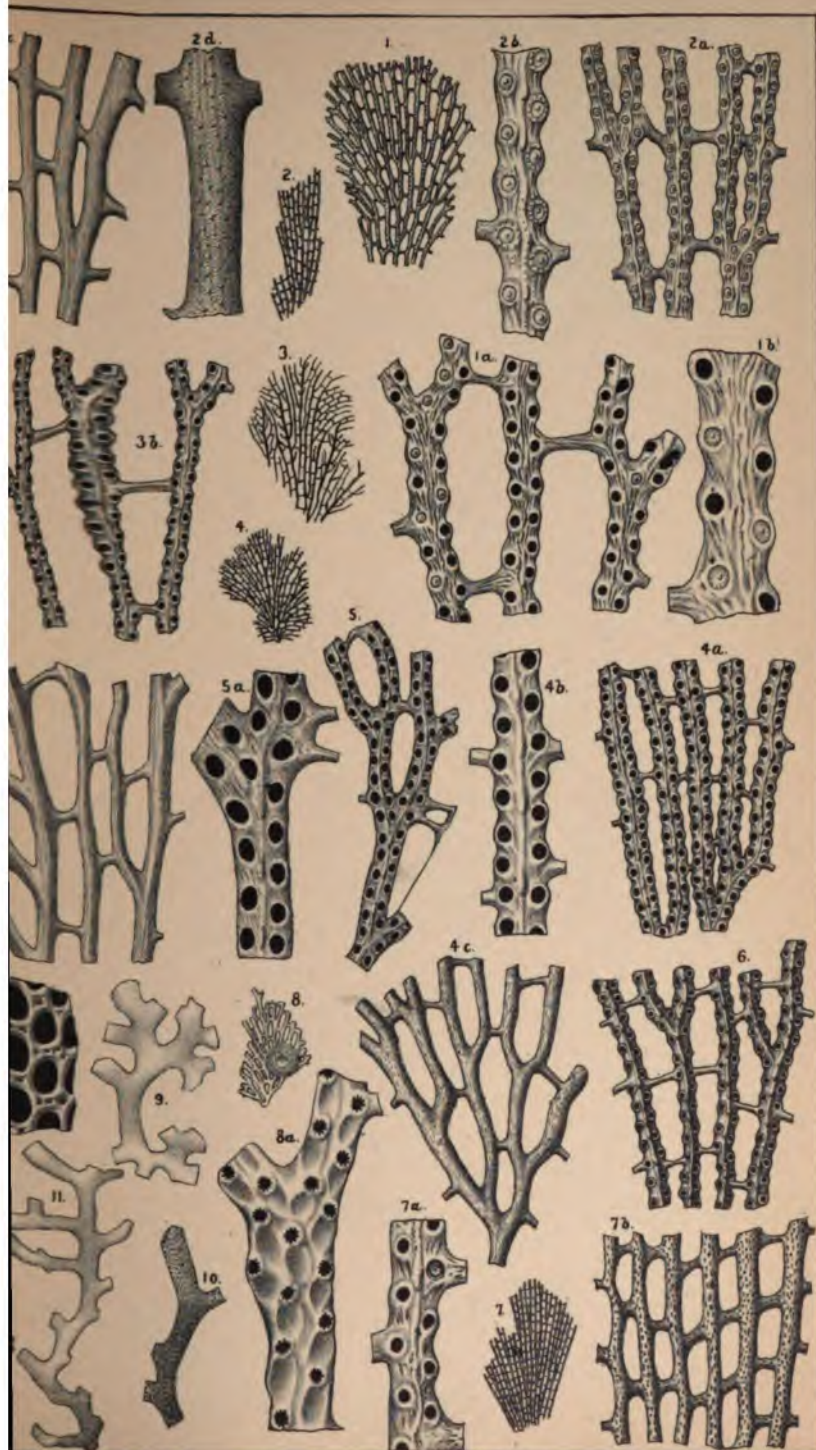
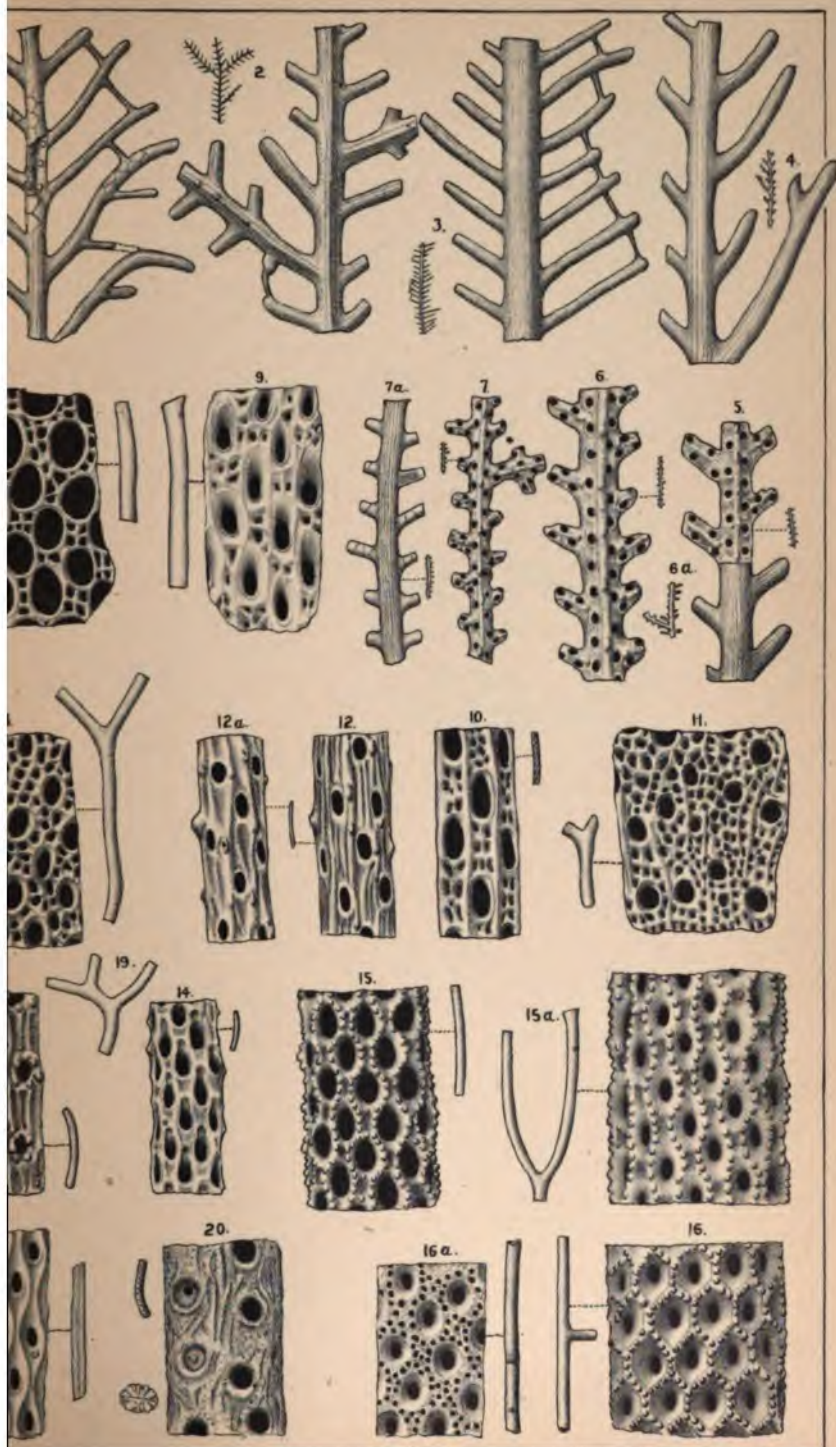


PLATE XI.





THE NEW YORK
PUBLIC LIBRARY
ASTOR, LENOX AND
TILDEN FOUNDATIONS.



THE NEW YORK
PUBLIC LIBRARY
ASTOR, LENOX AND
TILDEN FOUNDATIONS.

BULLETIN
OF
DENISON UNIVERSITY

VOL. IV., PART II.
[Educational and Literary.]

GRANVILLE, OHIO, JAN. 1st, 1889.

EDITORIAL NOTE.

The object of the department here opened in the bulletin is perhaps self-evident, but we may indicate that it is primarily intended as a common arena where the several departments and the constituency of this institution may meet for comparison of ideals and methods; and the crumbs that drop from the table of the various classrooms, if gathered and garnished, might serve for the intellectual quickening of many a stranger. We also intend to devote a certain amount of space in each number to the analysis of important educational works as well as to the study of striking tendencies, as exhibited in educational literature or praxis. The present issue is essentially an after-thought, and is to be treated as an explorer in a field where a little friendly co-operation would invite to permanent settlement. The frequency of issue will depend upon self-evident contingencies and will be independent of that of the laboratory portion, whose contributors freely admit that "the gleanings of the grapes of Ephraim is better than the vintage of Abi-ezer."

EDUCATIONAL BRIEFS.

"It is, indeed, a characteristic of fruitful ideas, that they as a rule are developed only in connection with a patient and penetrating investigation of some subject; nevertheless, such an occupation cannot be successful without some guiding theory."—LANGE. Hist. of Materialism.

It has been calculated that a shock sufficient to bring the earth to a stand-still in its orbit would evolve as much heat as the combustion of fourteen earths of solid carbon and result in a reduction of all the earth's elements to a fluid, if not mostly a gaseous condition. Moral:—If the earth moves, don't try to stop it. It is easier and safer to guide a natural tendency than to attempt to suppress.

In Chicago the writer once stood within the wonderful cyclorama, The Battle of the Merrimac and Monitor, when his attention was diverted by a group consisting of a burly, beer-imbued German of the lower class with his two children fresh from school. The children were full of eagerness and enthusiasm and were discussing this and that feature of the scene as appreciatively as a boy and girl only can after recent study of the history involved. Suddenly the father awoke to the fact that his age and position imposed upon him the office of cicerone. He accordingly pointed his stick, and with tipsy dignity began: "Now children, dose is not mans, dose is schust make-believes, dot is not air, de glasses make it look like it vas." "But father, isn't that the Merrimac?" broke in the boy. Vy no, dot is a boat, don't you see, dot is make-believe water, de glasses make it look dot vay. Dot is not vay off; Chicago is out dere, de glasses round here all makes it large about."

The pathetic humor of the incident could not prevent me from reflecting that much of our teaching is as faulty through ignorance and false estimate of the needs of the pupil as that father's description.

When a teacher finds that he has passed a year marking less of hard study and fresh attainment than any year of his student life, let him reflect that his successor has already been nominated. In the economy of nature after a body is dead, the time is not far distant, when it shall be written "Behold he stinketh."

Time was when the greatest difficulty under which the inland or (as Dr. Holmes would no longer say) fresh-water colleges in America labored was the lack of the perspective and stimulus afforded by a cultivated constituency. There were often enthusiasm and self-sacrifice, but too often there was but a very vague notion of what the ideals of college work should be. This is no longer in the same degree true, and the press has, as usual, been a prime mover in uplifting the plane of educational endeavor.

It is needless, then, to disguise the surprise which is felt when one sees in the editorial column of an inland Baptist paper—the *Journal and Messenger*, of Cincinnati—such a paragraph as the following:

"A pastor, in the families of whose church are a large number of college graduates, told us that there was hardly one of them that was good for anything as a church member."

To christian men of ordinary intelligence, the statement that college graduates are undesirable church members is susceptible of but one inference, namely, that a church in which such men can find no place or welcome is a strong-hold of narrow bigotry and ignorant egotism. The statement is a libel on the cultured church of America.

All educators are interested in the problem of university education in America. But there is much diversity of opinion as to the normal development and ultimate object of the university. A few points we, think, are settled in advance by the conditions existing in America. First, the continental university system cannot be grafted upon the American preparatory system. Our colleges undertake vastly more than the gymnasias of Europe, and turn out students at once better and worse prepared for the higher educational work. The Americans who enter German universities habitually take a high place among the ranks of original workers, though they may have cause to

lament imperfect preliminary drill. The sharp contrast between the routine of the gymnasium, and the freedom of the university, together with the resulting waste of time, are not necessary in America.

The true American university which shall be more than a pitiful imitation of an unnatural system must be the outgrowth of American experience and existing institutions.

So far, at least, as the scientific course is concerned, experience seems to indicate that the desire for the further pursuit of topics opened in connection with the collegiate studies furnishes the true *nexus* with the university course. No class, under favorable conditions, completes any scientific topic without furnishing several aspirants for the advanced work in the same line. When teachers and pupils are brought daily within sight and hearing of the investigations of advanced students, the attraction is greatly increased. The combination of college and university instruction under the same management affords opportunity for decided economy in apparatus, corps of instructors, and advertising, as well as in general endowment.

There is a characteristically American fallacy regarding the essentia of the higher instruction. The prime requisite is stated to be money. Of course, some money is necessary, but the lavish expenditure in buildings and in display-apparatus is foolish and unnecessary. The real essentials are two—men and books, but especially men. It may be replied that to secure the best instructors large salaries are necessary. But, as a matter of fact, the true teacher is not avaricious, and appreciates the spirit and scope of his work more than its rewards.

The man who is adapted to conduct truly original work is himself an investigator, and he will prefer to labor where time and appliances for his own studies are offered, with large liberty in laying out the work, rather than where a larger salary brings with it constraint and uncertainty.

The contact of a moment with a teacher overflowing with the contagious enthusiasm of a personal struggle with stubbornly concealed fact, is worth more than hours of routine drill under the *hired* instructor.

The typical American university will be, we believe, the outgrowth of the college. It must be remembered, however, that few of the graduates of American colleges are financially able to endure longer unaided the already exhausting drain. Some provision for assisting promising students must be devised. The most economical method seems to be that of active fellowships. There are always connected

with the university system many sorts of drudgery which require and confer discipline. A foundation which pays a small stipend for such assistance not only enables the student to pursue his studies, but relieves the instructor of much unproductive labor. In many cases, the gathering of material for a special investigation at once familiarizes the collector with the practical details of a subject, while supplying the experienced student with available material. The fact that this kind of assistance in no way compromises the self-respect of its recipient is no small argument in its favor. Certainly the church, as well as society at large, has need of well-trained teachers no less than of clergymen.

One of the significant signs of closer articulation between college life and what is known as "real life," is seen in the increasing amount of attention given in the college course to social and economic questions. Johns Hopkins, Harvard, Columbia, Cornell, the University of Pennsylvania, and the University of Michigan all supply courses in social science.

The practical study of such questions as immigration, poor laws, pauperism and crime, child labor and woman labor, unremunerated industries, etc., cannot fail to remind the student that he is not a member of a medieval monastery but a part of vital modern civilization, bearing his share of its responsibilities and burdens.

The question arises whether the benefits of such study can be offered the students in only a few exceptional colleges and in the universities. We think not. The inductive method is possible in connection with the term usually given to ethics or political economy. Thus, various students may be asked and assisted to collect and digest data on such topics as these in the adjoining city or community. What is the average school life of boys—of girls—of foreigners—of rich—of poor? What is the ratio of various employments in your township, ward, or school district and what is the remuneration of each? From what class or nationality do the criminals in your district chiefly come? What crimes are especially characteristic of uneducated, and what crimes find their victims among the more cultivated? What is the ratio of contributed to accepted charity? What proportion of the population is not reached by specific religious influence? In many branches of such investigation, the humane and religious institutions would gladly co-operate and the collection of statistics might be combined with charitable or religious work.

BOOKS AND AUTHORS.

LOTZE'S ONTOLOGY—THE PROBLEM OF BEING.

So long as man delights in the pure activity of reason, the fundamental question of philosophy will reappear in varied form.

To recapitulate the various views as to what constitutes being would be to review the course of philosophy from the Eleatics with their *Pure Being* to modern materialism with its omnipotent atoms. To define the terms employed in the discussion would be a repetition of the task of Wolff, who taught philosophy the modern tongue, and of the task of Hegel, whose subtle analysis seems to have exhausted the possibility of further dismemberment, if, indeed, it has not so divorced the essentials from the essence as entirely to dissipate being in the dust of formal logic.

No recent writer has contributed more substantially to the solution of this problem than Hermann Lotze, whose writings are just becoming known and appreciated in this country in spite of the inadequate and positively inaccurate translations which furnish the medium through which his thought reaches the English-reading public. Lotze is especially valuable on account of his clear statements of the limitation of the sphere of psychological investigation, and because of the tonic antagonism of his monistic idealism to the prevalent dualism or mechanical materialism.

We need at the outset to notice a peculiar apparent contradiction in his method. He explicitly states that metaphysic precedes psychology in natural order, and compares the reverse procedure to the tuning of instruments before a concert. Lotze correctly states that "every one must, in the last instance, judge of every proposition submitted to him upon grounds of which the constraining force presses upon him with immediate assurance." This is, however, far from convincing us of the irrelevancy of close inspection of the source, content, and relations of the given proposition. To his figure we might rejoin that to precede psychology by metaphysics is like painting a picture with an empty color-box. The contradiction is more apparent than real, for evidently Lotze would search for the metaphysical in the psychological content, for he says "the history of science shows that those who resolutely set themselves to mastering certain problems generally found their cognizance of the available appliances and of the use of them grew keener in the use, while, on the other hand, the pretentious occupation with theories of cognition has seldom led to any solid result." How to sever the content of cognition from the process of cognition becomes a hopeless problem from the subjective and dynamical point of view of our author, and need not be solved in practice.

The "idealistic construction of the universe", which Lotze regards as the attainable end of philosophy, does not construe the "dependence of the reals," (otherwise the order of nature) as referable to a fixed and arbitrary law—this is unattainable—but reaches only derived laws. Thus Lotze is world-wide from the older idealists. Indeed, this admission is fatal to a purely idealistic system, as its author evidently felt, and thus he was forced to elevate experience to a place from which the more consistent earlier idealists banished it. For the purely systematic creations of Aristotle and Kant he has little respect, regarding the categories, even as supplemented by Kant, as mere hap-hazard contrivances of psychologists.*

It is certainly a matter of surprise that he should chose, as his fundamental statement, the reality of the distinction between spirit and nature, as the two elements in our universe, and begin with the assumption that no period of human existence is conceivable when man did not feel himself in opposition to an external world—a psychological rather than a metaphysical determinant.†

This double inconsistency is again more apparent than real, for he proceeds to reduce everything to a common character of interdependence as immanent in the Infinite, from which some real beings (spirits) are elevated (without being liberated) into the sphere of transcendent existence—a realm of conscious freedom in real dependence, of which more anon.

Then, admitting the complete human subjectivity of our knowledge, he insists on its necessary validity in its own sphere, and builds unhesitatingly on it the structure which is subjected to a final searching test from an ethical point of view.

It is at present, however, with his doctrine of being that we are especially occupied. "Since sensation is the sole *causa cognoscendi* of being, we might make the mistake," says Lotze, "of identifying being with that which reveals it." The question pertinently arises what becomes of being when the only evidence we have of it is removed? The simplest form of answer lies in an appeal to the consensus of sentient beings. This informs us that the conditions of sensation are not solely incident to our individual nature. Just as the more concrete concept of substance is formed from the concurrent testimony of isolated senses, the separate but concordant testimony of various beings is the basis for an act of judgment, out of which rises the concept of independent being as a cause of subjective states.

Essence, says Lotze, must be prior to interaction, but it is equally true that the being of things is only to be found in the reality of certain relations between one and another. The quality of things by

*See for valuable critical notes on the categories, ULRICI, *System der Logik*.

†Nevertheless, he does not agree with Ulrici in taking the antinomies of consciousness as a starting point.

which they reveal themselves is due to change. The basis of his whole idea of essence is found in the statement, long since published, that "things do not exist by virtue of a substance contained in them, but that their existence consists in the power to produce a given appearance." This, in point of fact, is equivalent to identifying being with energy. Reality is another name for behavior. Such are some of the various ways of stating the same idea.

If being consists in activity, the being of two things in one universe would imply interaction—space is but another name for variety in the modes of this interaction. Our minds compel us to think of energy as a resident in *substance*. This is a necessary postulate of our minds, the correctness of which it is idle to discuss. The power of action and reaction resides in one infinite substance. All the elements of nature are immanent in this Absolute and the gradations of their existence depend on the intensity of the portion of the absolute within them.

An absolutely inactive soul would thus be a nonexistent soul. Immortality becomes a mere potentiality or, as the author himself suggests, a melody with pauses—every lifetime of this soul is a *deed* of the primal external force.*

There are several points in the conclusion reached which require interpretation, and some which seem neither to grow out of the premises nor to correspond with the positions elsewhere taken. In fact, in applying the system, Lotze seems at times to lean to the very verge of a mechanical construction which regards the soul as a condition, and then to fling himself to the other limit of regarding it as a self-centred being with unconditioned spontaneity.

Let us construe the problem of being on the basis suggested by Lotze, but following a slightly different path and remembering that the ultimate criticism of a system must be on the basis of its adaptation to the needs and postulates of the thinking subject. If we cannot, as Lotze claims, predicate from what ought to be what is, yet it will be generally admitted that if our subjective standards of reality fail, there is to us an end of philosophy.

Philosophy has been defined as world-wisdom, but it would be more unambiguous to define it as self-wisdom. "Self" is the necessary postulate and foundation of all knowledge. (Though we may agree with Biran that self reveals itself and the non-ego simultaneously in a sense of effort and its occasion.) This is the thinking object-subject, and knowledge of it is immediate and constitutes consciousness. Con-

*As regards the doctrine of being, many of Lotze's statements were anticipated by Cousin and (more correctly interpreted) by Maine de Biran. (*Œuvres Philosophiques*, Paris, 1841. It is especially in reference to the human will that Biran becomes explicit on this head. "Effort made by the will and directly perceived constitutes the individuality, the ego, the primary fact of the inner sense." The idea of force is the corollary to that of effort. It seems to us that this forms a valuable supplement to Lotze's idea.

sciousness reveals its content in two forms, active and passive—subjective and objective—distinctions which likewise are immediate in experience, though upon them rests the whole superstructure of psychology.

"Self," as subject-object with its active and passive phases expressed in *volo* and *patior*—the latter further analyzed by psychology into reflexive and independent, *sensibilitas* and *intellectus*, giving us the familiar trinity, will, susceptibility and intellect—must be the starting point for every excursus into the realm of being.

It must be admitted, however, that the criticism of Ulrici upon this point is valid.*

Ulrici's argument may be condensed as follows, chiefly in his own words:

The simplest reflection convinces that the idealistic principle—thought and its necessities—constitutes the cause and therefore the only starting point of philosophy.

I have also shown that this intellectual necessity implies, or is rather founded upon, the second or realistic factor of human knowledge, i. e. the activity of a real being. Indeed, thought would be impossible without this realistic factor, and this inheres in the nature of thought as one of its conditions. (Ulrici means by thought, "all spiritual activities or the spirit itself as activity.") We cannot doubt or deny the existence of thought, for such denial or doubt is activity.

This is the real meaning in Des Cartes' famous *cogito ergo sum* and this truth is the starting point of Kant, Fichte and Hegel. Nevertheless Ulrici is unwilling to proceed with Lotze from the fundamental ascertion "I THINK," because this is not an irresolvable and unambiguous concept, but rather from "IT IS THOUGHT," i. e., eliminating entirely the implied problem, "who thinks?" This thought must not be called with Fichte "my thought" for my thought is distinguished as *mine* only when compared with *his* or *yours*. It is quite incorrect to say with Lotze "my thought would obviously remain mine even though every other personality were suddenly annihilated," for, true as this is as a general statement, it would not be true in consciousness except as the memory or mental representative of these other personalities remained, thus taking the place of the actual personalities in my consciousness and continuing the process of comparison or contrast. The criticism thus applied to the concept *mine* applies equally to that of *I*. The self-consciousness implied in the word "I" Ulrici believes is itself a product of an effort of the intellect.

The only thing about thinking which cannot be denied or doubted is its active character, for even the denial is an effort of the intellect. Abstraction, denial, doubt, all are efforts of thought. It is impossible to go back of the primary statement *thought is activity*. As Trendelenburg has shown, all definitions of activity assume the knowledge of what is to be defined. Lotze, indeed, responds that it is possible to regard the phenomena of thought as a passive happening in which the mind is simply affected. "Fragen. Untersuchen. Wissen kann ich zwar allerdings als Thaten, als Handlung auffassen . . . ich kann jedoch ebensowohl dieses ganze innere Leben als eine Reihe von Zuständen, eine Geschichte ansehen, so dass das ganze Schauspiel meiner passiven Zustände entsteht, die ich bald Frage, bald Untersuchung, bald Wissen nenne." But we think he is fairly answered when Ulrici says, "the difference between Lotze and me consists only in this, he proceeds from definite concepts and their activity without inquiring into their origin or the source originating them, while I begin with thought as the force which originates these concepts. But, I ask, how can concepts be "in me" without my distinguishing them from

*System der Logik, Leipzig, 1852, p. 6, et. seq.

myself or one from another. Further, how is it possible to conceive of, not merely knowledge alone, but even questioning and research as merely passive conditions of the inner life?"

After all, Ulrici comes upon the ground here indicated when he adds, "Certainty is simply impossible without a something which is certain, (subject) and another something of which it is certain (object). Being certain of something is really the act of separating in the intellectual process the subjective and objective element. Thus the essential element in thought is discrimination or comparison."

We may accept Lotze's reasoning so far as to admit that being comes within the range of our consciousness only in the form of energy. All attempts to define that in which this energy resides prove illusory.* We discover, however, that in our own consciousness all these several forms of energy are efficacious—must be in order to rise into consciousness. This being so, there must be in us that which can convert all energies into its own. This fact, taken in connection with the inductive law of physics that all the material forces are correlated and convertible, warrants us in assuring the unity of all being in a common sphere.

That all forces are convertible implies the possibility of resolving all into one, in which case substance, the unknown ground of energy, reduces to a like level of uniformity—not a pleasant outlook. Let us trace this thought further. If all forces resolve into one then the possibility of reaction ceases, for in strictness, the same force, cannot operate in opposite directions. Where, however, all force is identical there is no display of energy, or, in other words, all has perished. It is then impossible to conceive of these extinct energies ever being re-

*In the attempt to mediate being and thought, Trendelenburg seeks a form of activity common to both. This he finds in motion, and, accordingly, motion is that definite form of activity which unites thought and being—activity is the universal, motion the particular.

Really, however, there is nothing gained by the apparent analysis over the more general statement that thought and being—soul and body—are inherently active. The common character of this activity is not proved to be motion, or, if both are assumed to be forms of motion, other proof is still needed to explain the interaction between them.

Lotze does good service in emphasizing the fact that materiality is not a self-evident condition of interaction between two beings. The other view is older than Lucretius.

"Tum porro varios rerum sentimus odores,
Nec tamen ad naris venientis cernimus umquam,
Nec calidos aestus tuimur nec frigora quimus
Usurpare oculis nec voces cernere suemus;
Quae tamen omnia corporea constare necessest
Natura quoniam sensus impellere possunt,
Tangere enim et tangi, nisi corpus, nulla potest res."

—*De Rerum Natura*, I, 298-304.

We conceive that the theory of being proposed above shows how the common-sense notion that similarity of attribute is a prerequisite to interaction originates. We have seen that the essential thing in attribute is activity. If two beings resemble each other, it is simply because they act in the same way; but acting in the same way in opposite nodes or multiple measure is the essence of interaction.

kindled except some adequate cause be applied to awake the reaction. This is excluded by our premise and, moreover, it is impossible to conceive how conflicting forces could ever destroy each other unless two universes are assumed, when, again, it would be inconceivable how interaction could begin between them. This endless chain of argument clearly shows that the collapse of the system through the sinking to a dead level—absorption in Nirvana—is impossible. Thus much to preserve us from an error into which Lotze seems to have nearly fallen.

If being is identified with energy and all being is immanent in the Absolute, it remains to account for the various kinds of being. From moment to moment we are affected by various sorts of stimuli the energy of each of which indicates to our minds a special being. Existence is, in conformity with the above argument, that combination of identity and diversity out of which grow our notions of sequence, cause and effect. Being as continuous, is existence. Existence implies correlated acts of energy in a stated order or method. Existence as self-continuing is life. In life the correlation is sustained from within rather than without. Life as self-conscious implies personality. The relations conceived as existing between these forms of being may be illustrated thus. Two currents of the celestial ether impinge and produce a musical note—that is being; this note varies according to a definite order, producing a melody—that is existence; the eddying forces act and react rhythmically, each impact producing the next—that is life; the notes are wafted back from the unknown in an echo to begin a new refrain, and thus indefinitely in a responsive theme—that is personality.

Lotze was driven by his line of argument to cast doubt upon the substantiality of the soul. But the same shadow must envelop all other kinds of *substance*. The only logical position seems to be pure agnosticism on this point. The energy implied in psychical existence is not denied, and this energy is the soul's being, no matter what its ground, and the sequence of its manifestations constitutes the soul's existence. If it be proper to speak of the life of a soul, it is found evidenced in the capacity to perpetuate its states and predicate its existence. If the soul is personal, it is so because it is conscious of this power, and thus responsible for its execution. Better substitute for what is meant by substantiality is not, for our purpose, necessary.

Lotze in an inconsequent way developed hesitation in postulating the immortality of the soul, chiefly influenced by pathological considerations and what seems to us an erroneous conception of time.*

*It is believed that modern philosophy has something to learn from Lucretius in the temporal discussion. The classical student will perhaps remember the following passage from Lucretius better than the metaphysician:

"Tempus item per se non est, sed rebus ab ipsis
Consequitur sensus, transactum quid sit in aevo,

Tum quae res instet, quid porro deinde sequatur.
Nec per se quemquam tempus sentire fatendumst
Semotum ab rerum motu placidaque quiete."

—*De Rerum Natura*, I, 459-463.

We have already seen that it is unthinkable that all force should be absorbed into one, and thus lost. Brief investigation indicates that the law of conservation of energy applies in all spheres, and that propagation of energy has its own laws.

Being is tossed on the waves of the "becoming," but becoming, in any other than a world of chance, constitutes existence. Self-propagating existence is such becoming as is conforming to the rhythm of the universal pulse, and hence is growing more and more indestructable. Personal existence adds to this conformity that self-consciousness which is but the promise of the highest conceivable state, where each part is conscious of the whole. The existence of the individual implies a law and a progression, this is termed development, while each individual forms part of a progression called evolution. Each of these factors has its counterpart in the nature of man, the first in memory, the second in heredity.

As in the working out of the individual progression (development) memory is a necessary condition, so is heredity an essential condition of the larger progression involving all living beings. But the second of these is seen to be in harmony with a progression expressed in the non-vital existences, in which a sort of memory is provided in *latent energy*, so-called. Thus we see all nature points in one way. First, beings range themselves in sequence producing existence. Inanimate existence is diversified into a great system and in this process lays up stores of latent energy. Living things move in accordance with similar laws and embalm them in heredity, while persons carry in memory the evidence of that path of development which they pursue. With the cumulative evidence thus furnished, shall we hesitate to form the legitimate induction that further evolution is possible? Conscience seems to correspond to memory in a sphere in which forces of a non-physical sort play in the same harmony seen in the more gross activities, and, by the far-reaching sanctions of its laws, conscience claims for its arena a wider domain than that of earth.

What Lotze means by speaking of the soul as a strain of music with pauses is hard to say, but such a conception as seems to be presented is out of harmony with his system as applied to personal existence and is contrary to his teaching elsewhere. Personal existence is a distinct advance on life, as life on existence, and existence on being, yet one grows out of the other and all have their residence in that Universal which, as we have seen, must unify all being in so far as there is a possibility of interaction. This progressive character and interdependence permits us to produce the chain inductively into the future as well as to trace it backward.

The onward sweep of evolution will ultimately overtake the sluggish flood of the physical which forms its present vehicle and beat out

its exhausted force on the unconscious shore of time. What then? Is the individual life, which has been its concrete product, but the luminous foam on the crest of the wave only to fall darkling in its trough? This is incompatible with our law of energy and progression. Where then is the next term of the series—the effect of which our evolution was the cause? In the soul of man there have awakened the unfinished harmonies of beauty, truth, moral worth, happiness. The sphere of these lies beyond the sensuous and in them lies the promise of further development.

If being is action, a pause in an uncompleted harmony would be its destruction. Harmony consists in relations of an orderly kind. To interrupt these relations would be to destroy them. However, this is not saying that *consciousness* is necessarily continuous. Evidently that is what Lotze had in mind when disturbed by pathology. Again, consciousness cannot be *consciously* interrupted, such an expression simply means that more or fewer stimuli are, for a time, warded off from the soul. When all the sensuous images of life fade with the body, what new vistas shall open on the soul—what new music continue the melody of familiar tones—who shall say! As the energy of the being grows more subtle and its range increases, a thousand new stimuli awake it to unfelt sensations and unconceived rapture.

This, it seems to us, is the logical induction from Lotze's idea of being. He himself said that the ultimate criticism of a theory is based on what nature ought to do. Let us see how the theory applies in the realm of human interest and activity.

If being is doing, the right to exist depends on the power to serve. "*Ich diene*" is the device on nature's escutcheon. Life is the rapturous pulse of every capillary in man's nature and happiness is the harmonious vibration of every well-stretched fiber of our being. In the fulfillment of every obligation—the response to every call, lies the promise of perpetuity. The survival of the fittest is no longer a blind and atrocious fatality, it is but the reverse aspect of the law of development. To be fit is merely to be, and being or activity is survival.

Of more practical interest is the personal application of this view. The essence of education and of growth is effort. Symmetrical education, in a true sense, is not so much an essential to success as success itself. In the idleness or inertness of any faculty lies the threat of its speedy extinction. Morality is not a possession but a power. Well-directed altruistic effort identifies self-interest and duty.

The nature which responds most readily to every stimulus afforded by nature, and sees the beauty, and hears the harmony in all, most truly is. It is not the stooping student, the acerbic anchorite, the blind devotee, or the disciple of pleasure, who truly lives, but the man of two worlds whose body moves in this world while his spirit inhabits in inalienable possession temples above the clouds. [C. L. H.]

NOTE—Publishers sending books for review should observe that scientific and educational rather than purely literary topics are germane to our purpose. Memoranda of price, etc., are also desired.

THE PERSONAL ELEMENT IN INSTRUCTION.

By C. J. BALDWIN, D. D.

Individuality is that which differentiates one human character from another. It is the cast or quality which gives to each man's work a distinct, unique effect. This element is already recognized as having a scientific value. It has been found that the individuality of a worker may and must be allowed for in determining the precise nature of his work. The "personal equation" has been formulated and used as a factor in the finest problems of applied science. Each observer, calculator, has a spectrum of his own in which the ray of truth which he transmits is crossed by dark lines peculiar to himself. And, just as analysis of the stellar ray reveals to us the chemical elements of distant stars, so may we find in the light emanating from separate minds subtle but sure indications of their inherent qualities.

If this were not so, literature of all kinds would lose much of its charm and power. The monotony of unrelieved sameness would soon check the student's enthusiasm, and one book would be enough. But, as it is, the same subject may present to us an infinite variety of aspects as different authors treat it in their diverse ways, each one shaping or coloring it after his own likeness. We find new meanings in the old truth each time it is translated into the idiom of a life.

Of all cases of this kind the teacher is the most prominent. It is his office to become a medium through which truth is to shine upon the learner. He originates nothing, but transmits or translates. How important then, the quality of the medium, whether it is clear or dim, dense or rare! We are continually noticing this in our text-books, the difference between authors in their power of elucidating and applying the same truths.

Individualism adds something of its own quality to the ray which it transmits. Manliness in the teacher ennobles any communication that he makes. Sympathy, moral earnestness, intellectual honesty, vitalize and recommend even the barest topics.

What a difference between Arnold's lectures on Roman History

and those of Niebuhr, in their power over the student! The secret of the charm which Neander and Tholuck threw over scholastic lore was found in their intense humanity. It was said of Robertson, the famous preacher of Brighton, that he could captivate the heart even when the reason was not convinced. Such is the power of the personal element.

Nothing can take its place. Erudition, critical skill, abundant apparatus, will not compensate for the absence of this attribute. Those who studied Moral Science under Wayland, or Psychology under Hopkins, or Theology under Robinson, or Botany under Gray, will testify that they received as much from the man himself as from the subject matter that he taught. Who could resist the enthusiasm with which Agassiz would describe a fish, or forget the electric thrill which accompanied Mitchell's lectures on Astronomy?

As to whether this power is the result of cultivation or is to be regarded as an original endowment, observation seems to favor the latter view. Some natures are evidentially more highly charged with this magnetism than others. It is one of the qualities of genius. And yet individuality can be developed and emphasized by culture. Whatever broadens or deepens the nature, inspires it with unselfish devotion to the truth and fills it with genuine knowledge, is sure to result, also, in new powers of expression. What we truly love that we are at no loss to describe and recommend.

It is true that strong personality sometimes takes the form of idiosyncrasies, mannerisms which culture corrects. A certain rounding of angles and smoothing of the surface is always the result of training. But, on the other hand, genuine growth insists on self-assertion; so that, if we become less unlike others, we are also more and more true to ourselves. There is an artificial education which robs character of all its originality and reduces personal traits to a uniform standard. Better the primitive wilderness of the forest than such Dutch gardening. But there is no loss of individualism, rather a gain of self-reliance and expression, in that development which true cultivation effects.

CHAMISSO AS NATURALIST AND PHILOLOGIST.

By PROF. GEORGE F. MCKIBBEN.

Upon Monbijou Square in Berlin there was erected in August last a statue to the poet Chamisso. The longest life-time has passed since his story, *Peter Schlemihl*, appeared,—a story written for children, which soon made its author known among civilized nations the world over. Tom Moore's *Irish Melodies* were in their day no more popular in English-speaking lands than were Chamisso's poems in Germany. Though not given to boasting, he could say in a letter written about 1830, "The people are singing my songs; they are sung in parlors; boys declaim them in the schools." This popularity is not yet wholly past; his poems have still a steady though not a large sale among Germans, having the especial distinction of being a very common gift-book for weddings and christenings. For Chamisso is beyond all question the German poet who has most acceptably sung of marriage and home-life. In Robert Schumann's musical setting of Chamisso's *Frauenliebe und Leben*, a group of lyrics unequalled by any who have sung of wedded love, we have that rare combination, music "married to immortal verse," in which each part enhances the beauty and power of the other.

His place in the literature of Germany has long been conceded; his poems alone entitle him to so much of fame. But in that which Germans call the "world-literature" he must also be accorded a place. His *Peter Schlemihl* bears translation, that searching test which tries the worth or worthlessness of a book. Who can read the story, perhaps in the English with Cruikshank's illustrations, without wonder at its ingenuity, deep and sensitive feeling, and sad but wise spirit? The reader probably wonders at another thing; that the hero, though isolated from his kind by his shadowless condition, yet, unembittered by his lost happiness, finds consolation in his power of roaming over the earth, "measuring now its heights, now the temperature of its springs, now that of the air; observing animals, examining plants; hastening

from the equator to the poles, and from continent to continent, comparing one observation with another." This is explained by Chamisso's possession of a claim to distinction in addition to his literary achievement; as a student of nature he deserves mention with Humboldt and Darwin.

Yet not as their equal. Both his general education and his special training were obtained under appalling difficulties. Born in Champagne of noble parents, Chamisso was but nine years old when, in 1790, his family fled from the ancestral castle, involved in the retribution which befell the guilty aristocracy of France. The father of the Chamisso family joined others of his order in the endeavor, with the help of Prussian and Austrian bayonets, to turn back the tide of Revolution. The sons accompanied their mother and sisters and began a really manly struggle for their support. The future naturalist was at one time about to learn the trade of a joiner; he did in his efforts to earn his bread gain some skill in making artificial flowers and, what was afterwards very useful to him, in drawing and painting. In the latter art his elder brothers had become proficient when in 1796, after wandering about Holland and Germany, Berlin became the home of the family. Adelbert became page to the Queen of Prussia and was enabled to study in the French gymnasium. Two years later he was appointed ensign in the Prussian army, in which he spent eight unhappy years, trying repeatedly to resign, until the sudden and crushing defeat of Prussia by Napoleon in 1806 released him. By this time, by dint of remarkable assiduity in private study he had gained an education of surprising thoroughness and breadth, and had written and published poems in both his native and adopted tongue. He had found friends also,—not among his fellow-officers, from whom he was isolated by nationality, tastes and studious habits and, it must be added, by considerable absent-mindedness; but in non-military circles he had found, as early as 1803, those with whom he formed life-long friendships. The turning point in his change from Frenchman to German was passed. Six years of rather aimless life in his native and

adopted country and in Switzerland only proved that he had taken root in Germany, and in 1812 he returned to Berlin with the purpose of giving his life to the study of nature, especially botany. The purpose had been formed in Switzerland while with the literary family of the famous Madame De Stael, in company with whose son Auguste Chamisso had taken his first botanizing excursions near Coppet.

The years 1812 to 1815 were spent at the new University of Berlin in the most untiring study of the natural sciences. No time was spent in verse making. The period of Chamisso's special studies saw the tremendous uprising of Germany against Napoleon's power, now shaken by the disaster in Russia, yet still formidable. Germany was chiefly the scene of the struggle. Chamisso naturally had no place in it, and remained passive in the midst of one of the most determined and enthusiastic efforts ever made by a people for its freedom. Berlin became unendurable to him; he retired to the country. But even here and in the midst of his beloved studies he could not forget the terrible conflict in progress. He took up his pen again, and wrote the story *Peter Schlemmhl*. This expresses, some think, fancifully but forcibly, the suffering of his sensitive soul at being "a man without a country." It expresses more plainly his longing to travel and study nature and thus forget human dissension. The opportunity soon came and was eagerly seized.

To gain glory as a patron of the sciences, the wealthy Russian chancellor, Count Romanzoff, was at this time preparing to send a ship on a voyage of discovery into the South Pacific and to find the north-east passage from Behring's Strait into the Atlantic. Chamisso obtained a position as naturalist of the expedition and on August 9, 1815, reported at Copenhagen on board the *Rurik*, a two masted vessel of only 180 tons, which was his home for the next three years. The captain was Otto von Kotzebue.

The voyage which gave to his scientific labors definite direction and material for the rest of his life, was Chamisso's first experience at sea. It brought him first to Plymouth, a few days after the captive

Napoleon had been carried thence to St. Helena; then southward to Teneriffe, Brazil, around Cape Horn to Chili; taking leave then of Spanish-speaking lands, for three months and a half through the islands of the Pacific almost without dropping anchor, to Kamtchatka; in the summer of 1819 through Behring's Strait into the Arctic Ocean and back among the Aleutian Islands, where preparations were begun for the polar voyage proposed for the following summer. In the interval, from September to March, the Rurik sailed to San Francisco, the Sandwich Islands and the Radack chain of the Marshall Islands, seeking chiefly supplies and only incidentally scientific information, it seems. On the return northward from this winter in summer seas there occurred the storm of April 18, 1817, in which the ship was damaged and the commander so injured that the main purpose of the expedition, the search for the north-east passage, was abandoned. On the map Kotzebue Sound, Eschscholtz Bay, Chamisso Island, all under the Arctic Circle, remain as reminders of the captain, the physician, and the naturalist of the Romanzoff expedition. The return voyage brought the Rurik again to the Sandwich Islands, and to the Radack group a third time; thence by the Marianne and Philippine Islands, through Sunda Strait, by the Cape of Good Hope, past St. Helena, (where the strict watch kept over "Prometheus upon his rock" made it dangerous, in the case of the Rurik, to land), on to England, Copenhagen again, and, finally on August 3, 1818, to St. Petersburg. Chamisso declined inviting offers to remain in Russia, was generously allowed to keep his collections, and in October reached Berlin, where he long enjoyed alone the distinction of having sailed around the world.

Though his purpose on returning had been to go upon another scientific journey soon, the remainder of his life was passed in Germany, and, excepting a few absences, in Berlin. For here in 1819 he was given charge of the Botanical Garden, and later of the Herbarium also; about the same time began his married life, which continued without a shadow until his wife's sudden death in 1837. He survived

only a year. His botanical discoveries upon the voyage began at the first port in which the Rurik anchored after he had got aboard. For near Plymouth he found the *Centaurea nigrescens*, previously unknown to English botanists. The unfavorable season, wet at Teneriffe, in Brazil, and dry in Chili, prevented successful collecting. It must be said, too, that Chamisso was not only not aided, but even hindered and thwarted in his duties as a collector by the captain: many carefully gathered specimens, especially sea-weeds, were by the latter's order thrown overboard when left to dry on the deck or in the cabin. This unfortunate circumstance and the limited space at his disposal make it remarkable that Chamisso could accomplish what he did. The flora of the thrice-visited Radack Islands was preserved almost complete. California, as yet almost untrodden by the botanist, furnished much that was new, among other things the *Eschscholtzia californica*, one of the Papaveraceae, named in honor of the ship's physician, who was also the naturalist's most helpful friend during the whole voyage. Seeds of this Californian flower, carried home by Chamisso, gave it a permanent place in the gardens of Berlin. An abundant collection was made upon the islands of the Arctic Ocean of plants which reminded him vividly of the Alpine flora of Switzerland. From the northern regions alone, visited by the Rurik, he brought to Germany more than fifty plants, which thus far had been unknown. The Cape of Good Hope, called the most thoroughly studied botanical garden on earth, furnished him several species new even to the trained eye of Mundt, a Berlin botanist whom he met there.

Though he began at once on his return to arrange his *herb*, as he called his plant-collection, yet he personally did but a small portion of the work. With rare unselfishness he distributed them freely to learned institutions, especially of Berlin, and to other especially qualified botanists, in whose hands they became the basis of many valuable investigations and conclusions. For example, he sent to the Swede Agardh, an authority upon sea-weeds, a collection of *algae* brought home from his journey, among them a rare example of reduplication, found

at the Cape in gathering tang. In this specimen Agardh saw an illustration of his theory of the transformation of plants to animals in the case of certain *algae*: an opinion which Chamisso, who held firmly to the permanency of types, was far from sharing.

The full value of his work as a botanist during the great journey appeared when, shortly after his death, Schlechtendahl, his colleague, published in the botanical journal, *Linnaea*, a description by families of the plants observed upon the Romanzoff expedition. In the name of several of these the discoverer's name is preserved; for instance, the *Cibotium Chamissoi* Kaulfuss, a most beautiful tree-fern of Hawaii.

Chamisso advanced the cause of botany not only by his plant collections, and by his official position, but also by his pen. Contributions to his friend Kunth's *Flora of Berlin* appeared at the same time with his *Peter Schlemihl* in 1815; at the direction of the Prussian government he wrote a book for use in the schools on the plants of North Germany, the introduction to which contains, as he said, his scientific confession of faith; as an editor of the *Linnaea* he wrote many minor botanical essays, to most of which he furnished his own illustrations, thanks to his skill with pencil and brush.

Thus far this article is about equally indebted to Chamisso himself, Max Koch, and an address delivered in June by Du Bois-Reymond before the Prussian Royal Academy of the Sciences. Among botanists, as the above paragraphs show, Chamisso deserves to be held in lasting remembrance. In other branches of natural history also he rendered valuable help by patient observation and happy suggestion. A quotation from Du Bois-Reymond shall speak for itself: "Chamisso himself was now to make in the domain of metamorphosis one of the most remarkable discoveries. Voyagers in the warmer seas had long observed certain animals, about as large as a mouse, soft, of glass-like transparency, iridescent in the sunshine, which often appear in great numbers upon the water's surface and present the peculiar phenomenon of being united, from 20 to 40 of them, in long chains by special organs of adhesion. These animals, mollusks without head or

shell, are the *salpae*. All members of such a salpian chain are of the same shape and similarly arranged; by taking in and forcing out water they move uniformly and keep step, as it were, and thus the whole chain rows along with serpent-like motions beneath the smooth surface of the sea. Besides the chains of *salpae*, isolated *salpae* also occur, but of two kinds. Some bear in their organs of adhesion plain trace of having been members of a chain; others entirely lack any such trace. On the voyage from Plymouth to Teneriffe during a calm, Chamisso made the surprising observation, that the isolated *salpae*, which never formed part of a chain, always contain spawn which resembles the chain of *salpae*; on the other hand he found in the members of the chain a spawn whose form corresponds to that of the isolated *salpae*. The animals which belong to a chain, and which produce isolated *salpae*, are hermaphrodites; but the isolated *salpae* are neuter, and the chains are produced in them without fertilization by budding. Two generations thus alternate, one of which is propagated sexually, and the other asexually by internal budding, and which are distinguished by other marks besides. To use Chamisso's figure: a *salpa* is not like its mother nor its daughter, but rather its sisters and its grand daughters."

"Chamisso named this kind of propagation that by alternating generations. So new and unheard-of did his story appear that, when he related it after his return in a special Latin treatise *De Salpa*, published 1819, it either remained unnoticed or was violently attacked. Meyen, later professor of zoology and natural history at the University of Berlin, who in the years '30-32 sailed around the world as ship's physician on the merchant-man *Princess Louise*, was so unfortunate as to meet with not a single isolated *salpa* that contained a budding chain of *salpae*, while free-swimming chains of *salpae* surrounded the ship in masses. In his doubts concerning the correctness of Chamisso's observations he went so far as to assert that the free-swimming chains of *salpae* and the chain-germs, which Chamisso claimed to have found in isolated *salpae*, had nothing at all in common. On the other hand Eschricht in Co-

penhagen assumed Chamisso's facts as correct, but in an extended treatise, in 1841, thus after Chamisso's death, proposed another explanation. * * * Almost immediately after this, in 1842, Chamisso's view found in the same place a defender, and his fame a herald, in our corresponding member Herr Japetus Steenstrup. He succeeded in distinguishing upon the wide field of the doctrine of propagation,—a field abounding in strange things,—a series of development processes, which as a whole can be explained from the point of view of alternation of generations, which Chamisso had first recognized and named. * * * Processes of development in the *medusae*, *strobilae*, *cercariae* and *distoma*, and *aphidae* or *plant-lice*, and later others besides, were thus at one stroke made plain. Johannes Muller's famous discoveries concerning the development of echinoderms formed a step of transition between the phenomena of alternation of generations and those of metamorphosis, of which the frog and butterfly afford the best known instances. The merit of having opened this way belongs, as Herr Steenstrup expressly declares, to Chamisso."

Though sharing in the erroneous view at the time prevalent concerning the coral insect (that it builds its wonderful structure up from immeasurable depths), yet he contributed to the understanding of the subject by observing that the coral grows most rapidly in a violently agitated sea. This more rapid growth, however, he did not ascribe to the real cause, (that the surf secures the insect its needed nourishment), but merely to the mechanical action of the waves. Not for the correct theory of their formation, but for his careful study of their present condition as the abodes of men, does he deserve credit in connection with the coral islands.

In concluding his discussion of Chamisso's contributions to zoology Du Bois-Reymond says: "We should be in error, if we imagined Chamisso's zoological observations directed, according to the manner latterly preferred, only upon the lower animal forms, such as salpae and coral insects. With just as close attention the vertebrate animals of all latitudes were observed: the flying fish, the birds that perched

upon the *Rurik*, the whales, which he dreamed of taming and making serviceable, the sea-lions through whose bellowing herd he fearlessly strode on St. George's Island. Concerning the monkeys taken on board of the *Rurik* he made profound psychological observations. Even the extinct animal-world did not go unnoticed: a tusk, dug up by Chamisso on Kotzebue Sound, was, in accordance with his drawing and description, ascribed by Cuvier in his *Ossements fossiles* to the mammoth."

"He must ever be regarded as the man who, by distinguishing two chief divisions of the great ocean and a separate group of islands, first shed light upon the mixture of races inhabiting the island-world. The present division into Micronesia and Polynesia * * was substantially made known by him. * * * In the north also Chamisso gave valuable hints concerning the relationship of the Asiatic Tchuktchis and the American Esquimos."

If the celebrated saying of Charles V. is trustworthy, that one is as many times a man as he knows languages, then Chamisso was a man many times over. His native tongue was always available and was resorted to for many practical, everyday purposes; papers on scientific subjects were occasionally written in French; he used it also in counting, and in making the first prose sketch of a poem, which was taking shape in his mind and demanding expression. His last important literary labor was the translation from the French of Béranger, his favorite poet, and French was the tongue in which he spoke during the long delirium that preceeded his death. He shared the interest in the medieval that marked the early romantic movement, and obtained accurate and extended knowledge of both the old French and German literature.

German may be said to have been the language of his pen rather than that of his tongue; he never became able to speak it fluently, or without a peculiar accent. Chamisso's knowledge of German, though not above criticism for colloquial purposes, was sufficient to make him an ornament to German literature in both prose and verse, as we have

seen. His native clearness and grace, united with the well-known characteristics of German, could not but produce unusual results.

The literatures of England, Spain, and Italy were open to him. He was able to talk with the captains of American ships, which he saw in every port and on every sea, and with British officers in Plymouth; though his conversation in their tongue was the only thing that induced those grave taciturn men to laugh. His Spanish, while yet in Germany, enabled him to read Don Quixote in the original; it served him in both hemispheres as naturalist, and at San Francisco as diplomat. His title to acquaintance with Italian may be indicated by the fact that he naturalized in German poetry the peculiar verse of Dante, employing it for example, in *Salas y Gomez*, perhaps his most admired poem. Russian he began on the Rurik, but soon abandoned, finding that his ignorance of the language served as a welcome and effective barrier against his too often uncongenial companions in the crowded ship's cabin. Yet we find among his poems translations from Russian as well as more recondite sources, like the Lithuanian and Icelandic. His ability to use and enjoy Latin goes without saying, and Greek, learned while a soldier, very early made Homer at least a delightful companion.

All this made Chamisso certainly a linguist, but perhaps not a philologist. His work, however, in the languages of the Pacific, though soon superseded by investigations of more favored travelers and, in some cases, of American and English missionaries, may entitle him to the second name. In collecting word-lists and other examples of three Polynesian dialects, those of the Philippine Islands, the Radack chain, and Hawaii, he performed a great work, which deserves mention. Kadu also should be mentioned, the native who accompanied the Rurik upon its second passage from Polynesia to the Russian possessions and back to his home, and who rendered valuable aid in Chamisso's study of ethnology and anthropology as well as of language. The Radack dialect, whose written form has since been a much discussed problem, was, by an expedient that at least served in recording daily acquisitions of words, reduced for the first time to writing.

While among the Philippine Islands he used his opportunity of studying the Tagal dialect. He was by no means the first to break ground here, Spanish missionaries having long before performed the labor of giving it written form. He was able, however, to compare the claims of its three rival alphabets, and, what is more important, to enrich the royal library at Berlin with a collection of Tagal literature, which is regarded as one of his most valuable acquisitions.

The Hawaii language became familiar to Chamisso within a limited range of ideas before any attempt had as yet been made to reduce it to writing. About 1835, shortly before his election to the Prussian Academy, (to which, by the way, Alexander von Humboldt proposed his name,) he reviewed his records made 16 years before. The language had meanwhile become one of books and newspapers. His former knowledge of it appeared, however, neither gone beyond recall from lack of use, nor entirely outgrown by later development. He therefore thought it not presumptuous to attempt the task, which death had shortly before compelled William von Humboldt to relinquish, of supplying the language, by the help of its newly made literature with a systematic grammar and dictionary. The only known papers read by Chamisso before the Academy were reports of his progress in the study of the Hawaii language. For this work completeness cannot be claimed, nor did he claim the knowledge of the languages of southeastern Asia which was necessary to the perfect understanding of the dialects of the Pacific Islands. He made known his investigations only in order to put into more capable hands "some hewn stones for the structure of science." Death interrupted him before his difficult undertaking was ended.

Thus modestly does he state in 1819 his conclusions with regard to the unity of human speech, then only beginning to prevail: "We suspect that he, who, equipped with proper knowledge, could survey and compare all the languages of speaking men, would recognize in them only different dialects derived from one source, and would be able to trace back roots and forms to a single stock."

hibit the vigor and sonorousness of the noble speech of the world-conquerors than does the weak-vowelled and close-mouthed English method.

As for the so-called Continental (i. e. German) way of pronouncing Latin, which about 1860-'75 was epidemic in many parts of this country, especially in the West, I judge that there is not one word which may be justly said in favor of its use by an English-speaking student. Like the English method, it is not and does not pretend to be the ancient way; it is to the German exactly what the English method is to the English-speaker, a conventional manner of pronouncing Latin words, so nearly as may be, according to the analogies of his own tongue. It is used, I believe, in all German schools. To the German it has very much to commend it,—to the American or Englishman, nothing whatever. That so many American colleges and schools should hastily abandon a method of pronouncing Latin which was indeed not the ancient way, but was at least natural to the learner and helped him to understand and to pronounce correctly thousands of English words, and that they should adopt in its place a method which also made no pretence of being the ancient way, and which had the very great disadvantage of being utterly unnatural to the student and of tempting him to mispronounce thousands of English words,—that this should be done, the true ancient pronunciation being all the while approximately known, seems to me to have been one of the strangest of all the vagaries of American pedagogy. It was perhaps the most curious phase of that indiscriminating Germanomania which has so often snatched at the form while entirely missing the spirit of German scholarship. The American student was naively supposed to be taking a long step toward German patience and thoroughness, when he learned to mispronounce Latin according to the German method.

As between the English and the reformed (or Roman) pronunciation of Latin, there is fair ground for discussion. We surrender much when we take either. Without a knowledge of the way in which

the Romans actually pronounced their language, its sound-changes are quite inexplicable. The farther the pronunciation adopted departs from the true—and the English departs from it very far and at many points—the more inexplicable the sound-changes become. Some of them, to one acquainted with that method only, are not only without reason but flatly contrary to reason. No accurate study of Latin phonology is possible without knowledge of the true sounds of the language. In philological work, also, comparison of Latin words with those words which in other languages are kindred with the Latin, but not derived from it, can be safely done by no one unacquainted with the Roman pronunciation. On the other hand, the young English-speaking student, in acquiring his Latin vocabulary, and in comparing with Latin words the immense element of English which is directly or indirectly of Latin origin, is very seriously retarded by the use of any other than the English pronunciation. Again, Latin poetry is incomparably more beautiful when pronounced in the true ancient way, with all the quantities carefully observed. Of course this cannot be done by those who use the English method. On the other hand, when we consider how exceedingly small is the number of those who in using the Roman method pay even the slightest attention to quantity (except in settling the accent) and that in the lower schools not one in a hundred, not one in a thousand teachers has a ready and accurate knowledge of quantities, the practical gain from using this method even in poetry are seen to be somewhat misty. Indeed, and this must always be the gravest difficulty in trying to pronounce as the Romans did, the quantity of so many vowels is unknown and seems likely ever to remain unknown, that any approach to accurate quantitative pronunciation (and the ancient pronunciation was essentially quantitative) seems hopeless. Of course, the most perplexing case is that of syllables long by position. Here all agree that the vowel was pronounced with its own quantity, short or long, regardless of the position of the syllable. But what is the quantity of the vowel in such a case? In some classes of syllables the ancient testimony is conflicting, in most

there is no ancient testimony of any weight, in many there is no ancient testimony at all. In some, the strong probability is that the vowel was long; in others, that it was short; in others, the chances are about equal. To say that we may call such vowels short unless it is certain that they are long, is an easy way of evading the difficulty; but it is hardly satisfactory to the enquiring student who is resolved to speak just as Cicero did. To direct him to pronounce them long when they are probably long, and short when they are probably short, is to impose on him a burden of investigation and decision from which the teacher himself might shrink. To pronounce without regard to quantity, above all to speak that astounding mixture of Roman and English (not unfrequently with a dash of the German) which so generally usurps the name of Roman, is a libel on a noble language, and ought to be odious to all who have any respect for either Latin or English.

I have spoken of the English method of pronouncing Latin as natural to the English-speaking student; and so it is, for it attempts to pronounce the words according to the analogy of the Latin element in English. Yet even this method is difficult of perfect attainment: for the words of Latin origin in English, though much less irregular in spelling and pronunciation than the Saxon words, are still far from regular; and a pronunciation of Latin after their analogy must exhibit corresponding inconsistencies. Thus *s*, which with the Romans had probably always the same sound, has in our pronunciation one sound in *seco*, another in *rosa*, a third in *Asia*, a fourth in *fusio*, and is silent in *scientia*; and, though the student would perhaps spontaneously pronounce these particular words correctly on account of the similar words in English, yet numerous cases arise where the direction to "pronounce as you would if it were an English word" is not at all satisfactory, since there may be no common English word similar to the one in question (*e. g.* *Phthia*, *sibi*), or the several English words similar to it may not all be pronounced alike (*e. g.* *vitium*, *cf.* vice, vicious; *facies*, *cf.* face, facial), or the similar English word may be

entirely misleading (*e. g. honoro, cf. honor*). The student, therefore, should not be left to "pick up" his English pronunciation of Latin, but from the beginning should be taught its rules and should be assiduously exercised in them, until he shall have learned to leave nothing to chance or to conjectural analogies.

Moreover, in case the reformed pronunciation is the one used, we can not too strongly and frequently impress upon our students the necessity of mastering the principles of the English method also: for this must, at all events, be used whenever there occurs in an English sentence any of the following: (1). Latin or Greek proper names, geographical, biographical, or mythological; (2). Latin (or latinized) words which have been adopted in English without change of spelling (*e. g., stratum, apparatus, bonus, syllabus, comitia*); (3). Latin law-terms, proverbs, and other short familiar quotations (*e. g., habeas corpus, in statu quo, e pluribus unum*); (4). Latin and quasi-latin scientific names (with some exceptions to be mentioned later). On this point, I believe, all authorities are entirely at one;—whatever system of Latin pronunciation we use, all the above-named classes of words and phrases must, when they occur in English sentences, be treated as English and pronounced accordingly. This is not only settled by authority, but also required by the clearest reasoning; for while some of these terms are used by only a few specialists, others are among the most familiar of every-day expressions, and between these two classes others stand at all intervals. Who could draw the line between the familiar and the unfamiliar, and say, "These shall be considered as natives, and those as aliens?" Such a distinction is evidently impracticable. More than into any other Germanic language, there is a constant current of words flowing easily from Latin into English without change, especially of technical terms called for by the insatiate natural sciences. No attempt to stay the tide can succeed; and it is well that all authorities agree that such terms, when needed and when properly formed, are to be treated immediately as a part of our language and pronounced according to the

rules which govern other words of the same origin. Here is the point where many teachers using the Roman method are open to severest criticism. They do not impress upon their students the necessity of using the English method in all the four cases above mentioned. It is to be feared that the teacher himself does not always understand that this is the rule. Certainly, in examining men who have been prepared for college in the public schools of this state, I find that almost invariably those who have used the Roman or the Continental method make, when translating into English, numerous and gross mistakes in pronouncing classical proper names, except a very few of the most common. *Cæsar* and *Cicero* are not mispronounced; but *Caius* is invariably Ki-us; the g in *Orgætorix*, *Gyas*, *Geryon*, is hard; the faithful *Achates* is Akah'-tās or Akah'-tēz; *Labienus* is Lah'-bi-ā'-noos or La-bi-a-nus; the *Sequani* and *Haedui* appear as Sa'-qua-nē, Sēk'-wa-nē, Se-quah'-nē, Hī-doo-ē, Hī-doo-I, and in various other disguises. Questioning usually elicits the fact that in translating into English the boy has been allowed to pronounce proper names entirely at random, or that he has even been instructed to pronounce the names in both English and Latin according to what was fondly supposed to be the Roman method,—being in fact the oddest imaginable jumble of different methods.

When we say, then, that the ancient pronunciation is approximately known, we must qualify by adding this statement, that, while we do know how the Romans uttered the long vowels and how they uttered the corresponding short, yet in very many syllables it is quite impossible to say whether the vowel is long or short. Of course these doubtful syllables, though so numerous, are still few when compared with those whose quantity is certain; but in case of even this last mentioned class, a huge difficulty arises for the faithful learner—the difficulty of remembering. In all the recent beginner's manuals, some of them very admirable and to a considerable extent truly inductive, it is assumed or expressly stated that the learner is to master the natural quantities of all the syllables in every new word and form as he

comes to it. Now I have no hesitation in saying that this is a burden which the average student can not bear, and which the brightest and most faithful student quickly gives up the attempt to bear. Even when all doubtful syllables are evasively classed with the short, the burden is still too great for any memory not phenomenal. To remember that *a* is long in *Mars* and short in *pars*, long in *actum* but short in *factum*, long in *sperans* but short in *sperantis* and probably *sperandum*; that *u* is long in *duco* and short in *duxi*, while *e* is short in *rego* but long in *rex*; that *i* is short in *ingero* but long in *infero*; to remember and readily use these and similar facts, apparently unclassifiable and inconsistent, is a most trying task to the young man who knows that he has only a part of one life-time to spend on Latin. Sooner or later he abandons the hopeless task (as his teacher has probably done before him); and his pronunciation of Latin words, except when he is reading a text with all quantities marked for him, is a piece of mere guess-work. I believe that this is not an exaggerated description of the Roman method as usually taught by good teachers to bright boys; and whether this endless guessing is likely to have a wholesome effect on the mind in its formative stage, seems to me to be a question worthy of serious consideration. As to this method as taught by the average teacher to average boys, the results are so grotesque as to be quite beyond my powers of description.

In scientific class-rooms, too, strikingly incorrect ways of pronouncing technical terms are prevalent. I am convinced that also this is due in large measure to false notions concerning the proper province of the reformed method of pronouncing Latin. Let me repeat that this method should be used, if at all, only in the Latin class-work, and that there is not a shadow of authority or reason for using it in the case of scientific terms, law phrases, or the other classes of words mentioned above. For all these there is only one correct way—the English. As some of the best school grammars have in late years ceased to give full rules for the English method, it may not be amiss

to give an account of it, with special reference to the most prevalent errors in pronouncing scientific names.

The scientific terms falling strictly under the rules for the English pronunciation of Latin are the following :

1. Real Latin words, including many generic names and most descriptive names of species. The specific names are, of course, adjectives.

2. Real Greek words, put into a Latin form and accented always according to the Latin rule. They are mostly nouns used as generic names.

In latinizing them, kappa is changed to c; alpha iota, to æ; omicron iota, to œ, (except in the ending -oides and a few other cases); upsilon, to y; and epsilon iota to I, sometimes to ě (the instances in which it is represented by ei are mostly mere blunders). Theta, phi, chi, become th, ph, ch, respectively, which are always to be reckoned as single consonants.

3. Modern derivatives and compounds from classical sources and with classical endings. They include nearly all names for divisions higher than genera, and likewise the vast majority of recent generic names, mostly compounds of Greek origin, but all in a Latin form.

4. Many quasi-latin words, not of classical origin but having a Latin ending and classical appearance, and falling readily under these rules (*e.g.* *Catalpa*, *Cuscuta*, *Robinia*, *Batatas*.)

A class of quasi-latin words (*e.g.* *Woodwardia*) subject to these rules only in part, and another class (*e.g.* *Whitey*) not subject to them at all, will be mentioned at the end of this article.

SYLLABLES.*

Each Latin word has as many syllables as it has separate vowels and diphthongs. Ae and oe are usually diphthongs and printed æ,

*I have tried to make more clear the following rules, by giving in parentheses the correct pronunciation of some of the words cited as examples. In some cases, where the pronunciation could be indicated without respelling, they

æ. When printed separately (unless by mistake), the e makes an additional syllable, as in *Danae* (dan'-a-ē), *Callirrhoe* (kal-lir'-ro-ē), *Meroe* (mēr'-o-ē), *Leucothoe* (leu-kōth'-o-ē), *Leucôn'-o-ē*, *Isoetes* (I-so'-e-tēz). On the other hand, beware of making two syllables out of one in words like *Ægilops* (ēj'-i-lops), *Maia* (Mā'-ya), *Hygeia* (hi-jē'-ya), *Harpyia* (har-pī'-ya). All words ending in āius, āia, ēius, ēia, have the accent on the ā, ē; and the i=y. Of course final e is never mute in words which retain their classical ending. Do not omit it in *Dir'-cē*, *Dirce* (dir'-sē), *Ate* (ā'-tē), *Clytic* (klish'-i-ē, 12), *Hecate* (hek'-a-tē), *Aphrodite* (āf'-ro-di'-tē), *Eunice* (yoo-nī'-sē, spelled wrongly in list of asteroids *Eunike*); but many words drop their classical endings and have anglicized forms in mute e.

ACCENT.

In words of Greek origin, the accent which they had before being latinized is entirely disregarded.

1. In dissyllables, accent the penult.
2. In polysyllables, (a) accent the penult if it is classically long by nature or position; (b) otherwise, accent the antepenult. No exceptions. If the penult is common, treat it as short.
3. In long words there is a secondary accent on the second syllable before the primary accent, if such syllable is classically long

have been syllabified and accented without parentheses. Such words are not italicized. In the words respelled in parentheses, the vowels marked long have their common English long sounds, as in mate, mete, mite, mote, mute; those marked short are sounded as in mat, met, fit, not, nut; ah, as a in father; a final, as in quota; other unmarked vowels as they would be in an English syllable of the same spelling; sh, as in shun; zh, as s, in pleasure; g, as in go; j, as in join; other letters have their usual English sounds. The division into syllables is to show the vowel sounds only, and would not in some words be correct for other purposes. The sign of equality between two words indicates that the first is pronounced as the second. For brevity's sake, when a syllable is long by position, I speak of the vowel as long by position. This can not produce confusion, as the English method does not distinguish between natural and positional length. A few small exceptions, a knowledge of which is not necessary for pronouncing scientific words, have been intentionally omitted. The secondary accent is marked ' '.

or is the first syllable in the word; otherwise, on the third before the primary. *Alopecurus* (a-lōp''-e-cū'-rus, 4; 8, c) *Eleochâris* (e''-le-ōk'-a-ris, 17, e; 18, c).

The accent, both primary and secondary, is of the highest importance, as by it the sounds of the vowels are largely decided. In order to know how to pronounce a polysyllable, we need to know the classical length of the penult, which fixes the primary accent. In some long words, we must also know the classical length of the second syllable before the primary accent, thus fixing the secondary accent.

4. It is to be borne constantly in mind that, after the accent is determined, the English pronunciation of a word has absolutely nothing to do with the classical quantities of its syllables. The sound of a vowel will depend partly on its being accented or not, partly upon the letters following it, sometimes on peculiarities of English words of similar form, but never directly upon its ancient length. As a matter of fact, most syllables classically long are in English *pronounced* short, and very many anciently short are *pronounced* long.

The classical length of the penult is generally obvious; but in numerous cases a Greek or Latin Dictionary must be consulted. The following rules cover most cases: they refer to the ancient length of syllables, not to the English sounds of the vowels, and are to be used only in deciding the accent.

5. A syllable is long, if it contains (a) a diphthong (*e.g.* Spi-ræ'-a); or (b) a vowel representing a diphthong (*e.g.* Sci-ū'-rus, from skia, shadow, and oura tail; Er-e-ge-nī-a, from the Greek *Erigeneia*); or (c) a vowel naturally long (*e.g.* a-trŷ'-pa, trŷpa, a hole; such words are few); or (d) a vowel followed by j, x, z, or any two consonants, in which case the vowel is "long by position" (*e.g.* Leu-cō'-jum, Hŷ-pox'-is, Os-mor-rhī'-za, Gym-no-sper'-mæ); but (e) note that when l or r follows f or any mute (p, b; t, d; c, g; ph, th, ch), the two are counted as one consonant, and do not make a short vowel long by position; *cf.* 15 and 17 d.

6. A syllable is short if it contains a naturally short vowel before a single consonant (or mute with l or r). A vast majority of vowels before a single consonant are short by nature.

7. A vowel is short by position before another vowel, a diphthong, or h. This rule covers the penult in all the host of true Latin words ending in -ius, -ia, -ium, -io, -eus, -ea, -eum. There is no danger of falsely accenting them.

8. But note that if a vowel represents a Greek long vowel or diphthong, it is not made short by position before another vowel or diphthong (e. g. Bryozōon, from zō-on, living thing). Here belong numerous words of Greek origin in Ia, ēa, ion, āis, ōis, ēus, of which many have been adopted as scientific names; as, On''-o-clē'-a, Cas''-si-o-pē'-a, De-i''-o-pē'-a, Tha-lī'-a, A-rī'-on, La-od''-a-mī'-a, Iph''-i-ge-nī'-a. They are very often mispronounced.

CONSONANTS.

9. Consonants are generally to be pronounced as they would be in the same syllables in any English word. A few points need to be specified.

10. Before e, i, y, æ, œ, pronounce c like s, and g like j; elsewhere, pronounce c as in come, g as in go (Gyrocēras=jī-rōs'-e-ras; *Cyclostoma*=sī-klōs'-to-ma; *Gyges*=jī-jēs; *Cynoglossum*=sīn''-o-glōs'-sum, 18, c). Ch=k always; th as in thing; ph as in physic; j as in join; x at the beginning of a syllable=z, (*Chiton*=kī'-ton; *Ichthyophagi*=īk''-the-ōf'-a-jī; *Xylophaga*=zī-lōf'-a-ga, 16 a).

11. If a word begin with an unpronounceable group (pt, ct, cn, gn, mn, pn, chth, phth, tm, ps) the first letter of the pair is not sounded (*Phthia*=thī-a; *pterus*=tē'-ris; *clenococoncha*=ten''-o-kōn'-ka; *pseudobuccinum*=sū''-do-būk'-sī-num); but in composition, after a vowel, both are sounded (*neuropterus*=nū-rōp'-te-ris).

12. ASPIRATION. When ci, si, and ti, follow an accented syllable and are followed by another vowel, they are pronounced she;

but if the preceding syllable end in a vowel, then si=zhe. *Senecio* (se-ne'-she-o, 17, e), *Clytia* (klīsh'-e-a, 18, c), *Cirsium* (sir'-she-um); *Artemisia* (ar te-mizh'-e-a); *Caesia* (se'-zhe-a). By exception, *Asia*=ā'-she-a instead of ā'-zhe-a, and *Asiaticus*=ā''-she-āt'-ī-cus.

Cy is aspirated in a few words before o (*Procyon*=prō'-she-on; *Sicyon*=sīsh'-e-on).

Ti is not aspirated after s, t, or x, nor in Greek names in -tion.

VOWELS AND DIPHTHONGS.

In general, a vowel or diphthong is sounded as it would be in the same position in an English word. A few points need particular notice.

13. Æ and œ are always sounded as e in the same situation would be. They are often wrongly sounded long when they should be short. *Dædalus* (dēd'-a-lus, 18, c, not dē-da-lus), *Ænōne* (ē-nō'-ne).

14. Au, and eu, when diphthongs, are always sounded long, as in the English words laud, feudal.

Y is always sounded as i in the same situation would be.

15. In the following rules, remember that the expression "a single consonant" includes all cases (except the few mentioned in 16, d) where a mute is followed by l or r. The two are counted as one so far as their effect on the sound of a preceding vowel is concerned, though they may be divided in syllabification: cf. 5 (e).

16. SPECIAL CASES. For convenience, I group together here certain exceptions to various rules.

(a). A final, or a in an unaccented syllable (not final) before a vowel or single consonant, has the obscure sound of a in quota and oracle (e.g., Gla-bel'-la).

(b). The peculiarities of a after qu, and of all the vowels before r, are exactly as in English.

(c). I final has its long English sound. In other unaccented syllables, except the first, it has its short sound; and before a vowel

this is nearly like e (Unio=ū'-ne-o). In words accented on the second syllable, i has its long sound when it is initial followed by a single consonant (I-thō-ne; cf., Gi-nor-ga), and when it closes the first syllable before a vowel (Di-ō'-ne, Li-ā'-tris).

(d). u has its short sound before bl (Pūb-lic'-o-la); and other vowels before gl, tl, thl, (*Ægle*=ēg'-lē, 13; *At-las*; Ath-lē'-ta; *Aglata*=āg-la'-ya). The above given exceptions to the following rules, being made simply to conform to the peculiar pronunciation of certain similar English words, do not give any trouble in applying, except in the case of initial syllables with i.

17. VOWELS SOUNDED LONG. Whatever its classical length may be (4), a vowel is pronounced long in the following situations:

(a). Before a vowel or diphthong; *Euproops* (ū'-prō-ops), *Geum* (jē'-um); but note exceptions under 16, (a), (c).

(b). At the end of a word; but note 16, (a).

(c). In an unaccented syllable (not final) before a single consonant; Le-ō-nū'-rus, Blē-phil'-i-a, Cū-ni'-la; but note 16, (a), (c).

(d). In an accented penult before a single consonant (or mute with l or r, 4); *Stachys* (stā-kis), strā-tum (not strah'-tum or strāt'-um), *Phryma* (fri'-ma), mā-trix, Lichas (li-kas), Lythrum (li-thrum, not lith-rum), A-trī'-pa (not a-trip'-a), Cŷ'-pris, Arum (ā'-rum, not ah-rum), mā'-ter (not mah-ter or māt-er), Cnicus (ni-cus), nī-gra (not nig-ra), Mī-tra, stō-ma, Clē-thra, Is''-o-pŷ'-rum.

This rule is without exception. Mistakes are very common, especially in dissyllables, sometimes arising from a vague feeling that the classical quantity ought to determine the English sound, sometimes from regarding gr, tr, thr, etc., as having the effect of two consonants, sometimes from mistaken analogies with common English words.

(e). In words like Gā-li-um, As-tē'-ri-as, Mō-ri-o, Pte-le-a, i. e., where an accented a, e (or æ or œ, 13), or o comes before a single consonant followed by two vowels of which the first is e (æ, œ, 13), i, or y, Gō''-nī-a-ti'-tes, Ha-lō-ni-a. Here belong the host of words ending -aria, -onia, -aceae, -alia, -ania, -enia, etc., (but, of course, not those

in -icia, -ilia, -inia, etc., for the first of the three vowels must be a, e, or o).

18. VOWELS SOUNDED SHORT. Whatever its classical length (4), a vowel is pronounced short in the following cases:

(a). In final syllables ending in a consonant; but final -es is pronounced like the English word *ease*. *Athyris* (ath'-i-ris), *Atropa* (ât'-ro-pa), *Myriopoda* (mîr''-e-ôp'-o-da), *bicolor* (bîc'-o-lor), *Schizodus* (skîz'-o-dus), *Macrochilus* (măc''-ro-ki'-lus), *Promacra* (prôm'-a-cra), *Polypora* (po-lip'-o-ra), *Dolichonyx* (do-lik'-o-nix), *Trichostema* (trîk''-o-stê'-ma), *Fel'-i-dae*, *Granatocrinus* (grăn''-a-toc'-ri-nus).

(b). In any syllable before two consonants (except a mute with l or r).

(c). In any accented syllable (except the penult) before one or more consonants. Of course, it makes no difference whether the accent is primary or secondary.

To this most important rule there are two exceptions only:

(1). All words described under 17, e:

(2). The vowel u before a single consonant (tû'-ni-că'-ta, sũ''-bu-lî'-tēs). This (18, c) and the rule for accenting polysyllables with short penult (2, b) are closely connected. Both are very frequently violated, often in the same word,—far more frequently than any other rule.

It is to be especially noted that, while the first vowel is long (17, d) in such words as *Fe-lis*, *Ca-nis*, *A-phis*, *sto-ma*, it is short (18, c) in such as *Fel'-i-dæ*, *Can'-i-dæ*, *Aph'-i-des*, *stom'-a-ta*. All names of families in -idae have the penult short.

In nearly all compounds of Greek origin, the penult vowel, when followed by a single consonant, is classically short; and the antepenult is accented and pronounced short. Here belong all words ending in the following: (The same word may appear in different compounds with various endings, -us, -a, -um, es, -os, -on, -e, -is, etc. Only one form is given. The preceding vowel is retained in some cases to prevent confusion with other endings).

—cephalus (head).	—philus (loving).
—ceras (horn).	—phorus (bearing).
—crates (strength).	—pteris (fern).
—crinus (lily).	—pteryx (wing).
—cylcus (circle).	—pterus (fin).
—domus (dwelling).	—phytum (plant).
—dromos (running).	—physis (nature).
—genes (race).	—poda (foot).
—gnathus (jaw).	—pora (pore).
—lepis (scale).	—phagus (eating).
—lysis (loosing).	—spora (spore).
—machus (fighting).	—spila (spot).
—meris (part).	—strophæ (turn).
—odus (tooth).	—stylus (style).
—odon (tooth).	—stoma (mouth).
—opus (foot).	—sthenes (strength).
—ypus (foot).	—tropæ (turn).
—ipus (foot).	—thyris (little door).
—obolus (throwing).	—tomus (cut).
—omphalus (umbilicus).	—trephes (nourish).
—onyx (nail).	—triche (hair).

The following have the penult long :

—anthera (anther).	—nice (victory).
—chilus (lip).	—nema (thread).
—chirus (hand).	—otis (ear).
—damia (conquering).	—pogon (beard).
—dorus (gift).	—stema (stamen).
—genia (born).	—spira (spire).
—gyra (ring).	—theca (case).
—ites (stone).	—trema (hole).
—lites (stone).	—trypa (perforation).
—mene (moon).	—urus (tail).

In pronouncing these long words, heed must be taken of the secondary accent also. Æ and œ are shortened under rule 18, c, whenever e would be; Cæcidae (sēs'-i-dē), Ænothēra (ēn'-o-thē-ra), Ægilops (ēj'-i-lops).

Two classes of scientific terms, represented by *Woodwardia* and *Whyteyi* respectively, I have already referred to as not coming under these rules. The former class consists of modern proper names which have been latinized in part only. They have the endings, -onia, -ensis, -ia, -ii, etc., and are accented according to the general rule; but the unlatinized part retains its own pronunciation (sometimes slightly effected by the change of accent.)

The earlier rule in latinizing proper names was to give them a purely classical form. The result was often to render them nearly or quite unrecognizable. The present tendency is to preserve the identity of the name. A. S. Miller, in the preface to his *American Palæozoic Fossils*, argues that the rules of the British Association do not go far enough in this direction. He defends such forms as *Whiteyi* on the ground that White and Whitey, Case and Casey, Moor and Moore, will be confused, unless the -i be added to the name unchanged. In such forms as *Whiteyi*, *Smithi*, *Blacki*, *Blackici*, the part before the -i is to be pronounced exactly as if the i were not there.



SP1

Bausch & Lomb Optical Co.,
Manufacturers of the
Leading American **Microscopes!**
Objectives and Accessories,
Photographic Lenses, and Other Optical
Instruments.

Factory and Main Office,
531-543 NORTH ST. PAUL ST.
ROCHESTER, N. Y.

Branch Office
48 AND 50 MAIDEN LANE,
NEW YORK.

Just Completed,
By advice and assistance of Prof. Geo. H. Williams,
Johns Hopkins University, a series of
~~~~~**New Petrographical Microscopes!**~~~~~  
Complete Illustrated Catalogue on application.

PUBLISHED MONTHLY.

COMMENCED JANUARY, 1888.

**THE AMERICAN GEOLOGIST,**  
ILLUSTRATED.

Is conducted by a number of geologists who are actively engaged, professionally, in some of the branches of geology, and who are scattered over the

Northern and Central Parts of the United States.

It is calculated to serve as a repository of geological information and an aid to the earnest student and teacher. It publishes original observations contributed by well-known geologists, reviews current geological literature, defends the interests of geologists and the cause of geological instruction.

Every Student of the Rocks,

Whether he be interested directly in their constitution and their products or in their origin and history, will find *The American Geologist*

A USEFUL, INSTRUCTIVE AND SUGGESTIVE JOURNAL.

Subscription per Year is \$3.50; Single Numbers, 35c.

The numbers for 1888 (2 vols.) will be furnished to new subscribers who remit in advance \$2.

EDITORS AND PROPRIETORS:

Prof. Samuel Calvin, University of Iowa, Iowa City, Iowa.  
Prof. Edward Claypole, Adelphi College, Akron, Ohio.  
Dr. Persifer Frazier, Franklin Institute, Philadelphia, Penn.  
Dr. Lewis E. Hicks, University of Nebraska, Lincoln, Neb.  
Mr. Edward O. Ulrich, Geol. Survey of Illinois, Newport, Ky.  
Dr. Alexander Winchell, University of Michigan, Ann Arbor, Mich.  
Prof. Newton H. Winchell, University of Minnesota, Minneapolis, Minn.

Correspondence should be addressed to any of the editors, or to

**THE AMERICAN GEOLOGIST,**

MINNEAPOLIS, MINN.



# PHOTO ENGRAVING CO

ENGRAVING  
FOR ALL  
PURPOSES

67-71 PARK PLACE  
NEW YORK



BULLETIN  
OF THE  
Scientific Laboratories  
OF  
DENISON UNIVERSITY.

EDITED BY

W. H. TIGHT, M. S.,

DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

VOLUME V.

WITH TWENTY-ONE PLATES.

CONTENTS:

|      |                                                                                                                     |          |
|------|---------------------------------------------------------------------------------------------------------------------|----------|
| I.   | Editor's Statement .....                                                                                            | p. 1     |
| II.  | Exchange List .....                                                                                                 | p. 47    |
| III. | Laboratory Notes—                                                                                                   |          |
|      | 1. Germination of <i>Phoenix dactylifera</i> . Illustrated                                                          |          |
|      | Mrs. J. E. Dixon .....                                                                                              | p. 2-6   |
|      | 2. Botanical Notes. H. L. Jones .....                                                                               | p. 10    |
|      | 3. A Convenient Injecting Apparatus. Illustrated. W. G. Tight .....                                                 | p. 11-13 |
|      | 4. A Simple Spirometer. Illustrated. W. G. Tight .....                                                              | p. 14-15 |
|      | 5. Notes from Physical Laboratories—1. An Instrument for Rapidly Changing The Cell Arrangements of Large Batteries: |          |
|      | a. A Simple Chronograph; 3. Scale Divider; 4. An Electric Couple for Projection. Plate B. A. D. 1502 .....          | p. 16-21 |
|      | 6. A Specimen of <i>Hesperophona vespertina</i> . W. G. Tight .....                                                 | p. 22-23 |
| IV.  | Communications—                                                                                                     |          |
|      | 1. The Waverly Group. W. F. Cooper .....                                                                            | p. 24-32 |
|      | 2. Tabulated List of Fossils known to Occur in the Waverly of Ohio. W. F. Cooper .....                              | p. 33-38 |
|      | 3. The Central Nervous System of Rodents. Preliminary Paper. Plates I-XIX. C. L. Herrick and W. G. Tight .....      | p. 35-97 |

GRANVILLE, OHIO, JUNE, 1906.

132



PUBLISHED MONTHLY,

COMMENCED JANUARY 1888.

# The American Geologist.

ILLUSTRATED,

A strictly Geological Journal

Two volumes of 400 pages each, per year,

**Subscription \$3.50 Per Year**

All back numbers and the subscription for 1890, \$8.00.

## EDITORS AND PROPRIETORS.

Samuel Calvin, *June City, Ind.*

Edward W. Clappool, *Akron, Ohio*

John Eyerman, *Easton, Pa.*

Persifer Frazer, *Philadelphia, Pa.*

Clarence L. Herrick, *Cincinnati, O.*

Andrew C. Lawson, *Qitana, Ont.*

Robert Hay, *Jackson City, Conn.*

Arthur Lakes, *Golden, Col.*

Edward O. Ulrich, *Newport, Ky.*

I. C. White, *Morgantown, W. Va.*

Alexander Winchell, *Ann Arbor, Mich.*

Newton H. Winchell, *Minneapolis, Minn.*

Published at Minneapolis, Minn.

## BAUSCH & LOMB OPTICAL COMPANY

MANUFACTURERS OF

Microscopes, Objectives

And Accessories.

Photographic Lenses.

AND OTHER

Optical Instruments.



Factory and Main Office,

533-543 N. S. Paul St.

Rochester, N. Y.

P. O. Drawer 292

Branch Office:

48-50 Maiden Lane,

New York City

P. O. Box 432.

12th Edition of Illustrated Catalogue free on application.

**NEW PETROGRAPHICAL MICROSCOPE**—Made by advice and assistance of Prof. Geo. H. Williams, Johns Hopkins University.

BULLETIN  
OF THE  
Scientific Laboratories  
OF  
DENISON UNIVERSITY,

EDITED BY  
W. G. TIGHT, M. S.,  
DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

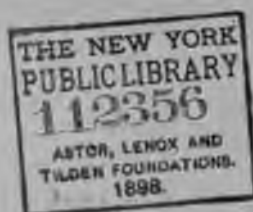
---

VOL. V.

WITH TWENTY PLATES.

---

GRANVILLE, OHIO, JUNE, 1890.



KUSSMAUL & SHEPARDSON,  
PRINTERS, BOOKSELLERS AND STATIONERS.

Granville, Ohio.



## EDITORIAL STATEMENT.

---

In presenting the Fifth Volume of the Bulletin to the public, it has been our intention to bridge over, as far as possible, the break which is the result of the change in the administration of the Geological and Natural History Departments. We take this opportunity to thank those who have contributed to our museum and otherwise encouraged the work of the departments. Obligations are expressed: To Prof. B. F. McKibben, for a collection of Lower Silurian fossils; to Mr. E. Clark, for a collection of minerals and lithological material from various points in the Rocky Mountains; to Mrs. Delano, for a large collection of shells, star fishes and numerous other zoological specimens; to C. J. Herrick and W. H. Cathcart, for much time and labor spent in identifying, labeling and arranging the Herbarium; to Prof. C. L. Herrick, for a large collection of minerals; to numerous scientific societies and persons who have contributed to our library; to others who have aided in various ways the work of the departments, but whose names may not appear, caused by change of the administration. We publish elsewhere the list of those persons and societies which give equal change of publications, but would ask the pardon also of any who may have been omitted from this list by mistake. As this issue is supported entirely by voluntary contribution we would mention our indebtedness for the larger part of the means to Hon. E. J. Barney, Hon. J. B. Thresher, Hon. E. M. Thresher, Hon. Albert Thresher, Dayton; Prof. C. L. Herrick, of University of Cincinnati; Prof. D. Cole, Prof. G. F. McKibben, Prof. H. L. Jones and Prof. W. Johnson, of the Denison Scientific Association. We would also thank Prof. C. L. Herrick for his aid in planning the work and reading some of the proof sheets.

It is hoped that this volume will partly represent the original plan of the publication and that its scope may be extended as larger means are provided for the work.

## II.

### BULLETIN EXCHANGE LIST.

The following is the list of the universities, academies, societies, individuals, etc., which make equal exchange with the Bulletin of the Scientific Laboratories of Denison University, and to which the Denison Scientific Association expresses thanks for many and valuable additions to its library :

|                                                  |                              |
|--------------------------------------------------|------------------------------|
| Academy of Science of St. Louis,                 | L. Nambac, Librarian,        |
|                                                  | St. Louis, Missouri.         |
| Elisha Mitchell Scientific Society,              | Chapel Hill, North Carolina. |
| Public Museum,                                   | Milwaukee, Wisconsin.        |
| Philosophical Institute of Victoria,             | Melbourne, Australia.        |
| Royal Society of South Australia,                | Adelaide, Australia.         |
| University of Tokio, Science Department,         | Tokio, Japan.                |
| Connecticut Academy of Science and Art,          | New Haven, Connecticut.      |
| Sociedad Cientific Argentina,                    | Buenos Ayres, S. A.          |
| Real Academia de ciencias exactas,               | Madrid, Spain.               |
| Naturforschende Gesellschaft für dem Gesamten,   | Germany.                     |
| Naturwissenschaften,                             | Bern, Switzerland.           |
| Societas regia Scientiarum Upsaliensis,          | Upsala, Sweden.              |
| Kongl Velenskaps Akademie,                       | Stockholm, Sweden.           |
| University of Lund,                              | Lund, Sweden.                |
| Naturforscher Verein,                            | Riga, Russia.                |
| Academia real das ciencias,                      | Lisbon, Portugal.            |
| Kaiserliche Academie der Wissenschaften,         | Vienna, Austria.             |
| Kongl Boehmiche Gesellschaft der Wissenschaften, | Prag, Bohemia.               |
| Naturwissenschaftlicher Verein für Steirmack,    | Graz, Austria.               |
| Real Academia delle Scienze,                     | Naples, Italy.               |
| Royal Society,                                   | Edinburgh, Scotland.         |

- Natural History Society, Dublin, Ireland.  
 Society Royal des Sciences, Nancy, France.  
 Musee Royal d'histoire Naturelle de Belgique, Brussels, Belgium.  
 Kongl Danske Videnskalernes Selskab, Copenhagen, Denmark.  
 Konigliche bayerische Akademie der Wissenschaften,  
 Munich, Bavaria.  
 Medicinisch Naturwissenschaftliche Gesellschaft, Jena, Germany.  
 Naturhistorisch medicinischer Verein, Heidelberg, Germany.  
 Naturforschende Gesellschaft zu Halle, Halle, Germany.  
 Konigl Gesellschaft der Wissenschaften, Göttingen, Germany.  
 Senckenbergische Naturforschende Gesellschaft,  
 Frankfort-on-the-main, Germany.  
 Gesellschaft f-Natur-and Heil-kunde, Dresden, Saxony.  
 Boston Public Library, Boston, Massachusetts.  
 Secretary de, S. A. Mgr. le Prince Albert de Monaco,  
 16, Rue Saint, Guillaum, Paris.  
 Cornell University, Prof. H. S. Williams, Ithaca, New York.  
 Prof. Alexander Winchell, Ann Arbor, Michigan.  
 Naturwissenschaftlichen Verein zu Bremen, Bremen, Germany.  
 Manchester Literary and Philosophical Society, F. Nicholson,  
 36 George street, Manchester, England.  
 Library University of Minnesota, Minneapolis, Minnesota.  
 Dulan and Co., (3 copies), London, England.  
 Friedlander and Son, (3 copies), Berlin, Germany.  
 Prof. James Hall, Albany, New York.  
 Society of Natural History, Cincinnati, Ohio.  
 Royal Society of Canada, Montreal, Canada.  
 Stanley Hall, Journal of Psychology, Baltimore, Maryland.  
 Johns Hopkins University, Baltimore, Maryland.  
 Geological Survey of Indiana.  
 Geological Survey of Pennsylvania.  
 Geological Survey of Ohio.  
 Geological Survey of New Hampshire.  
 Prof. E. O. Ulrich, Newport, Kentucky.  
 Brookville Academy of Natural History, Brookville, Indiana.  
 University of Rochester, Rochester, New York.  
 Examiner, 38 Park Row, New York.  
 Royal Society of Victoria, Melbourne, Australia.

- Royal Society of Canada, S. E. Dawson,  
 233 St. James street, Montreal, Canada.  
 Natural History Society of Montreal, Montreal, Canada.  
 Historical Library, J. T. Browne, Springfield, Massachusetts.  
 Newberry Library, Dr. W. F. Poole, Chicago, Illinois.  
 Canadian Institute, Toronto, Canada.  
 Societe Zoologique de France, Paris, France.  
 Washburn University, Prof. F. W. Cragin, Topeka, Kansas.  
 Prof. E. A. Smith, Tuscaloosa, Alabama.  
 Essex Institute, Salem, Massachusetts.  
 Official Geological Survey, Washington, D. C.  
 United States National Museum, Washington, D. C.  
 Museum of Natural History, Central Park, New York, New York.  
 Museum of Comparative Zoology, Cambridge, Massachusetts.  
 Syracuse University, Prof. Underwood, Syracuse, New York.  
 Canadian Geological Survey, Ottawa, Ontario.  
 Prof. N. H. Winchell, Minneapolis, Minnesota.  
 American Philosophical Society, Philadelphia, Pennsylvania.  
 Illinois State Laboratory Natural History, Champaign, Illinois.  
 Prof. S. A. Forbes, Champaign, Illinois.  
 Davenport Academy of Science, Davenport, Iowa.  
 Prof. J. D. Dana, New Haven, Connecticut.  
 American Academy of Arts, Boston, Massachusetts.  
 Institute Royal Geological de Swede, Stockholm, Sweden.  
 Norske Geologiske Undersaegelse, Christiania, Norway.  
 Society Imperiale des Naturalists, Moscow, Russia.  
 American Naturalist, D. E. Cope,  
 2102 Pine street Philadelphia, Pennsylvania.  
 Prof. E. U. Claypole, Akron, Ohio.  
 Natural Historical Society, Glasgow, Scotland.  
 Journal of Microscopical Society, Bath, England.  
 Peabody Museum, Salem, Massachusetts.  
 Leopold Carol Deutsch Academie zu Halle, Halle, Saxony.  
 Linnaean Society of New South Wales, Sidney, Australia.  
 Societe Geologique de France, Paris, France.  
 California Academy of Science, San Francisco, California.  
 Geological Survey of the United Kingdom,  
 Jermyn street, London, England.  
 Prof. Edward Orton, Columbus, Ohio.

|                                       |                                |
|---------------------------------------|--------------------------------|
| Library School, Prof. Dewey,          | Albany, New York.              |
| Amherst College, Science Department,  | Amherst, Massachusetts.        |
| Cambridge Philosophical Society,      | Cambridge, England.            |
| Royal Irish Academy,                  | Dublin, Ireland.               |
| Ufficio Geologico,                    | Rome, Italy.                   |
| Comite Geologique,                    | St. Petersburg, Russia.        |
| Institute des Mines,                  | St. Petersburg, Russia.        |
| New York Academy of Science,          | New York City, New York.       |
| Prof. J. M. Kemp, Cornell University, | Ithaca, New York.              |
| Patent Office Library,                | London, England.               |
| R. Accademia Delle Scienze Di Torino, | Torino, Italy.                 |
| Societa Reale Di Napoli,              | Naples, Italy.                 |
| National Academy of Science,          | Washington, District Columbia. |

Others who desire to make exchanges with the Association for its Bulletin, will please address the Permanent Secretary of the Denison Scientific Association, Denison University, Granville, Ohio.

### III.

#### LABORATORY NOTES.

##### 1. GERMINATION OF PHOENIX DACTYLIFERA.

(Presented to the Scientific Association, October 29th, 1889.)

At one of the meetings of the Scientific Association, early in April, some members of the society asked how the date seed (*Phoenix Dactylifera*), germinated; whether the shoot came from out the little groove in the seed, from either end or from the back, and if it was always uniform or depended on the position of the seed.

During the informal discussion which followed several opinions were offered, but, as no one seemed positive about the matter, a committee was formed to study into the subject and report at some future meeting. I was chairman of the committee, and failing to find any satisfaction from numerous books consulted, determined to find the desired information by means of a series of practical experiments.

In a box of loose soil composed of sand, loam and leaf mold, I planted six well developed, healthy date seeds. They were planted in different depths of earth, ranging from 4 inches to  $1\frac{1}{2}$  inches from the surface of the box, and were each in a different position—one vertical, one horizontal, one inclined to the right and one inclined to the left and one each with the groove up and down, as seen in Plate A.  
*Fig. 1.*

The seeds were planted the first week in June, were kept in the sun as much as possible and watered with hot water. The 10th of August signs of life began to show themselves. By the last of the

month six slender, shining parallel veined linear leaves were waving gracefully above the soil. I let them grow in the hot sun until the 1st. of September, then I carefully removed the earth from around them and put them in a glass jar. The method of germination is illustrated in Plate A, *Fig. 2*.

In every case the radicle had come from the smooth side, even when it had to make quite a curve in order to turn its point into deep soil and the plumule springing from the convexity of the radicle starts upward. Thus proving that the germination is invariably the same, always rising from the center of the back of the seed and sending forth at the same time two growths, one downward, terminating in roots and rootlets, and the other upward, forming the leaf and eventually the tree proper.

MRS. J. E. DIXSON.

---

[EDITOR'S NOTE.—We take the liberty to insert, Plate A, *Fig. 3*, a pen sketch after Sachs' diagram, of the cross section of the date seed I, and germination of the same, II and III, showing internal arrangement of plumule, &c.]



## 2. WINTER FLOWERS.

H. L. JONES.

(Presented before the Scientific Association January 11th, 1890.)

The winter of 1889-90 will long be remembered for its extreme mildness. The effect on flowers was remarkable. Spring, summer and fall flowers were found growing side by side with one another. The following is a partial list of those blossoming in this vicinity in the winter months, with the date of each :

|          |     |                                          |             |
|----------|-----|------------------------------------------|-------------|
| November | 6.  | <i>Pyrus malus</i> .                     |             |
| "        | 17. | <i>Houstonia caerulea</i> , L.           |             |
| December | 1.  | <i>Sisymbrium officinale</i> , Scop.     |             |
| "        | 1.  | <i>Achillea millefolium</i> , L.         |             |
| "        | 23. | <i>Taraxacum officinale</i> , Weber.     |             |
| "        | 27. | <i>Claytonia Virginica</i> , L.          |             |
| January  | 6.  | <i>Viola tricolor</i> , L.               |             |
| "        | 6.  | <i>Hamamelis Virginica</i> , L.          | All winter. |
| "        | 6.  | <i>Stellaria media</i> , Smith.          | "           |
| "        | 6.  | <i>Cerastium viscosum</i> , L.           | "           |
| "        | 6.  | <i>Capsella bursa-Pastoris</i> , Moench. |             |
| "        | 6.  | <i>Lepidium Virginicum</i> , L.          |             |
| "        | 6.  | <i>Draba verna</i> , L.                  |             |
| "        | 6.  | <i>Makva rotundifolia</i> , L.           |             |
| "        | 11. | <i>Viola odorata</i> , L.                |             |
| "        | 11. | <i>Acer</i> , (species ?) cultivated.    |             |
| "        | 11. | <i>Ulmus Americana</i> , L.              |             |
| "        | 25. | <i>Salix discolor</i> , Muhl.            |             |
| "        | 25. | <i>Salix</i> (species ?).                |             |
| "        | 25. | <i>Houstonia caerulea</i> , L.           |             |
| "        | 25. | <i>Symplocarpus foetidus</i> , Salisb.   |             |
| February | 15. | <i>Erigenia bulbosa</i> , Nutt.          |             |
| "        | 15. | <i>Claytonia Virginica</i> , L.          |             |
| "        | 22. | <i>Vinca minor</i> .                     |             |

The Italics mark plants which have been introduced or are found only in cultivation. It is to be noticed the large per cent. they form of the number, being more than half. On January 3d, 1889, *Phlox subulata*, L. was found in blossom, but careful search this year failed to reveal any specimens until spring.

### 3. A CONVENIENT INJECTING APPARATUS.

BY W. G. TIGHT.

(Presented to the Scientific Association, October 5th, 1889)

There is a demand in every biological laboratory for some sort of an injecting apparatus. The syringe is good in its place, but when an experiment is to be performed in which it is necessary to know the exact amount of pressure, to have the pressure uniform and constant we must look to other means. To be sure, there are instruments constructed which meet this demand, but they are generally expensive and hard to obtain.

The mercury column has been utilized in various ways, but the volume required makes that also very expensive.

The bucket of water hung on a hook on the wall, with a tube leading to a pressure bottle below, is also good in its way and easily arranged and inexpensive, but no means is provided to regulate the pressure and as the bucket becomes empty the pressure gradually falls.

In the instrument about to be described the following benefits are to be derived: The expense is within a few dollars at the greatest; the pressure can be accurately regulated from zero to four pounds (or more, if a higher standard is used); the pressure is constant as long as there is any liquid in the upper flask; the pressure can be easily increased as injection advances; and requires no attention after it is once started, so that a difficult injection can be conducted by one person, as he can devote all his attention to his canula and the operation. It may stand on its own merits.

The following is the description of the instrument used in our laboratory, a drawing of which is presented by A of Plate A, *Fig. 4*.

The base board is 2x15 feet; the standard 2 in.x2in. 8ft., graduated to feet and half feet. Upon the standard is attached a small bracket by means of a friction clamp.

The shelf is braced to a small piece of wood one inch thick and two inches wide; to the lower end is attached a small metal band which clasps the standard; while the upper end is secured by a stiff wire bent as shown at E, (*a*, front view, *b*, side view), with the points of the wire inserted in the sides of the slide piece near its upper end and the wire passing around the standard.

Upon this bracket rests a gallon flask; a glass tube passes through the stopper (which is of rubber) to the bottom of the flask. On the lower end of the tube is arranged a small valve (B) which is made by placing a short section of rubber tube which just fits the glass tube over the end of the tube and a little longer section of a little larger rubber tube over the first rubber section, a small glass cone is then made by drawing down a glass rod or tube. This small cone fits in the end of the glass tube and is kept from falling out by a small pin passed through the diameter of the rubber tube below it. This allows the free passage of the air into the flask, but stops the water from passing up the tube in case there should be any back pressure. The end of the tube should be ground and smooth and greased a little so as to make a water tight valve. At the lower edge of the flask a small hole is made with a round file and in this is inserted a rubber tube about eight feet long, which opens into the pressure bottle.

Another flask of the same capacity as the first is used as a pressure bottle.

The rubber stopper is perforated by three tubes which pass just through the stopper. The tube to which the long rubber tube is attached must not have an orifice more than a quarter of an inch in diameter, else air bubbles will pass back up the tube when the pressure reaches its maximum.

Another tube is bent, as shown in the diagram, so as to come along the side of the flask. This tube is filled half full of mercury and is graduated up and down from the zero point in half inch divisions; then a half inch reading on either scale records an inch mercury column, equal to one half pound of air pressure in the pressure bottle. At the open end the diameter of the tube is diminished and it is curved a little to exclude dust.

The third tube bears a rubber tube, to which is attached a glass cross or metal piece, giving three outlets. To these are attached rubber tubes leading to the injection bottles. Three injection bottles are used, one for normal salt solution, one for red and one for blue gela-

tine, (or other coloring injections). All the rubber tubes are provided with thumb pinchers. The advantage of the three pressure tubes is obvious, as the normal solution may be used and then by closing the pincher leading to the pressure flask the pressure is all ready for the colored injections and, in case both colors are to be used at once, both injecting fluids will be under the same pressure.

Our injection bottles C, are made of clamp top cans, by drilling two holes through the top to one side of the clamp, a little larger than the glass tube to be used, thus allowing a rubber collar to be used around the glass tube and furnishing a movable and air tight union. The long tube which reaches to the bottom of the bottle is the one to which the canula tube is attached. If all unions are tight the flow of the liquid from the upper to the lower flask should force an equal bulk of injecting fluid from the injection bottles, less the amount of fluid required to produce the first pressure, with a single charging of the apparatus.

A saturated salt solution is found to work admirably as a pressure liquid. The pressure is regulated by shifting the friction bracket and the pressure is read from the mercury scale.

#### 4. A SIMPLE SPIROMETER.

W. G. THURNTON.

(Experimented with before the Scientific Association, March 8th, 1890.)

The apparatus here described and figured on Plate A, *Fig. 5*, is one which was constructed for and used by the class in Practical Physiology. The apparatus was constructed for the determination of the vital capacity, supplemental, tidal and complemental air, also for experiments on the increase of vital capacity by regular exercise of the respiratory mechanism. The results were so satisfactory that it was thought that others might wish to use the same plan, as the construction is very simple.

A board about 10 in. x 16 in. x 1 in. forms the base; at the center of one end is braced an upright piece 1 in. x 1½ in. x 28 in.; to this at the top is also bracketed an arm 1 in. x 1½ in. x 12 in.; a large stone jar is used to hold the water and rests on the base board; a large glass jar (in our instrument a zoology preserving jar), having a capacity of something over 4,000 c. cm., is graduated from the bottom up into 50 c. cm. divisions by adding water and marking the different levels; after this is graduated, a small hole is made with a round file in the bottom of the jar and a rubber tube with a glass mouth piece attached; the jar is then suspended bottom side up over the water jar, (by three wires which pass around it), by a wire which passes through a small pulley at the end of the arm and then through another nearer the standard and having a weight attached to the end of the wire just equal to the weight of the jar; the rubber tube is provided with a strong thumb clamp.

To work the instrument, open the thumb clamp, press the air receiver down into the water jar as far as possible; then by suction draw the water up into the air receiver until it is full of water. The re-

ceiver now rests on the bottom of the water jar and enough water remains in the water jar to protect the open end of the receiver and exclude the air.

To get the vital capacity, fill the lungs with the largest possible inspiration, place the tube to the mouth, open the clamp and empty the contents of the lungs into the receiver, at the end of the greatest possible expiration, close the clamp, read off the volume of air in the receiver, from the scale.

When the first air is sent into the receiver from highly inflated lungs it is under some pressure which is about balanced by the weight of the water in the receiver, but when the water in the two vessels is at the same level, if more air is sent into the receiver it finds little or no resistance, as the weight then begins to act to support the weight of the receiver.

To determine the three factors of the vital capacity of the lungs, the experimenter should be seated and should time his regular respiratory movements and should use the receiver about half full of water in order to obviate suction or resistance as much as possible.

It was found by the use of this instrument that the vital capacity of the class was a little above the average and that by blowing the vital capacity regularly twice every day those students whose vital capacity was far below the average at the start, could be brought up to above the average in the course of two or three weeks. It is recommended as a simple, cheap, and convenient lung strengthener.

## 5. NOTES FROM THE PHYSICAL LABORATORY.

### 1. AN INSTRUMENT FOR RAPIDLY CHANGING THE CELL ARRANGEMENT OF LARGE BATTERIES.

(Presented to the Denison Scientific Association, April 5th, 1890.)

One of the greatest difficulties in the way of the teacher of Physics who believes in the thorough application of inductive methods, is the great amount of time necessary for the systematic development of his subject. This difficulty meets both the lecturer and the laboratory director. It happens constantly, for instance, in a lecture course on electricity—and not infrequently in courses on other branches of physical science—that some question is asked that can be satisfactorily answered by even a moment's use of an electrical current of a definite strength and potential. But the demonstrator, not having just the right kind of current immediately available and being pressed for time, is met by this alternative: he may take five or ten minutes of time that he really needs for the demonstration of a more important point, to set up a battery, perhaps at the risk of wearing out the patience of his class, or, unwilling to make such a sacrifice, he may content himself with the unsatisfactory answer, that *if* he had time to do so and so, such and such a result would be obtained. In either case he is likely to lose the attention of his class and fail to produce conviction in their minds. The laboratory director feels even more keenly than the demonstrator the need of having all the laboratory facilities completely and immediately under his control. Many an earnest laboratory student loses interest in his work because he is compelled to waste so much time in simply getting ready for each experiment or determination that he makes. There is great need of more and better regulating devices in physical lecture room and laboratories. The instrument shown in plan and elevation at the end of this article, Plate B, *Figs. 1 and 2*, is designed to supply one need, namely, an electrical current easily adapted to a wide variety of uses. It gives at a moment's notice a current of any ampere strength and voltage within a considerable range, by changing the arrangement of cells in a large



battery to any one of a great number of combinations. The instrument illustrated is adapted to control a battery of twelve, twenty-four, or some multiple of twelve cells.

It consists of a base *a*, of thoroughly seasoned wood or ebonite, upon which is fixed a double row of flat, rectangular pieces of brass, 1, 2, 3, etc., each two or three centimetres long, one centimetre wide and one half centimetre thick. Each is fixed to the base by two round-headed machine screws, *d* and *e*, which fit into holes bored nearly through the brass from the under side and tapped out to fit the screws. The plates are so placed that the spaces between the rows are of the same width as the spaces between single plates. All are of equal size except two, 12 and 13, at opposite ends of the upper and lower rows; these are twice as long as the others. The plates may be connected like the coils of a resistance box, by flat plugs of brass shown in end and side elevation at *b*, and *c*, *Fig. 2*. Binding screws are soldered on at that end of each row which terminates in a short piece of brass. From these wires lead current to any desired point. Each plate in the upper row is connected to the positive terminal of a battery of one or more cells and each corresponding plate in the lower row with the negative terminal of the same battery. Thus, plates 1 and 13 form the terminals of one battery, and 2 and 14 of another. The battery wires are firmly held by one of the two screws of each plate, as shown at *f*. It is well to glue strips of wood, *g g*, under the ends of the base so that the screw heads will not have to be countersunk. To show how connections are made, suppose the simple case where each brass plate is the terminal of a single battery cell. In *Fig. 3* we see at *a*, how the plugs must be inserted to give an arrangement of twelve cells in series, at *b* the arrangement of twelve cells parallel, at *c*, the combination of six cells in series and two parallel, and at *d*, of three cells in series and two parallel. If the cells are of the Leclanché type, each with an electromotive force of 1.4 volts and internal resistance .7 ohm, we would have in the several combinations

|                                      | a      | b    | c    | d           |
|--------------------------------------|--------|------|------|-------------|
| Electromotive force,                 | — 16.8 | 1.4  | 8.4  | 4.2 volts.  |
| Internal resistance,                 | — 8.4  | .06  | 2.1  | .53 ohms.   |
| Current with no external resistance, | — 2.0  | 23.3 | 4.   | 8. amperes. |
| “ “ 1 ohm “ “                        | — 1.8  | 1.3  | 2.71 | 2.74 “      |
| “ “ 5 ohms “ “                       | — 1.3  | .27  | 1.04 | .96 “       |

This table shows the range of power possible by a moment's ad-

justment of the instrument. If the resistances of the various pieces of electrical apparatus in the laboratory are measured, a moment's calculation will show just what arrangement will give the greatest amount of current, or any amount desired, with a certainty and precision that is very satisfactory. This increased precision is possible with so little trouble by the use of this cell-connector that it is well worth one's while to gain it.

Larger batteries can be managed either with a similar instrument having a greater number of plates and connecting plugs, or by attaching to each pair of plates in the form described, a battery of cells, arranged in series or parallel, according as high potentials or heavy currents are most required.

Another form of the instrument has been tried. It is more easily made, but is less convenient in use. It consists simply of two rows of binding posts on a base. These are connected by short wires in various ways, for various combinations. Two rows of metal contact points, each carrying a sliding switch which could be placed upon the next point of either the same or the other row, would also be a convenient form. By this method, however, there would be difficulty in securing good contact between points and switches.

This instrument is especially useful for a complete experimental proof of Ohm's law. A student with one of them, an ammeter and voltmeter, or in place of the last two, a tangent galvanometer having both low and high resistance coils, can verify the law for a large number of representative combinations in a wonderfully short time.

It has been found a great convenience in this laboratory to have one of them upon the demonstrator's desk, with a dozen open-circuit cells attached. These require no attention for six months at a time, are always ready for use and do not polarize seriously in the short time necessary for an ordinary lecture experiment. The "old reliable" of the laboratory, a ten-cell plunge battery, has been thrown out of employment since the advent of the cell-connector. It is surprising how much can be done by the open circuit cells, with the aid of their powerful auxiliary.

It is hoped that it may prove as great a convenience in other laboratories as it has in this. Evidently it can be used with secondary batteries as well as primary. In this way it gives perfect control of very heavy currents.

## 2. A SIMPLE CHRONOGRAPH.

The apparatus illustrated on Plate B, *Fig. 4*, can be made in any laboratory, and is for many purposes a good substitute for an expensive chronograph governed by clock work. It consists of an electrical pendulum *a*, suspended on a steel knife edge, which makes and breaks circuit by carrying a platinum wire through a drop of mercury at *b*. The same circuit contains an ordinary telegraph sounder with a long bent wire attached, so that every depression of the armature makes a dot on a long strip of smoked glass, which can be drawn slowly along the table in front of it. A large turning fork, carrying a short piece of very fine wire as a stylus, makes a tracing, simultaneously, about one half a centimetre to one side. This fork is conveniently supported by being inserted into one end of a piece of wood *c*, which is hinged at *f*, to the table. The amount of pressure of the stylus is regulated by a wooden screw passing through *c*, and pressing against the table. If the pendulum is adjusted to beat seconds and vibrated through a rather large arc so that the sounder works with a sharp, short click, the period of the fork may be very accurately determined. The close agreement of a number of independent determinations indicates the accuracy of which the method is capable. This is shown in the following series of four successive experiments:—

| Experiment. | Times. | Vibrations. | Vibrations per Sec. |
|-------------|--------|-------------|---------------------|
| 1           | 8 sec. | 440.7       | 55.09               |
| 2           | 6 "    | 330.2       | 55.03               |
| 3           | 6 "    | 330.6       | 55.10               |
| 4           | 5 "    | 275.1       | 55.02               |

---

Average number of vibrations per second, 55.06

If it is desired to measure any other short interval, having thus accurately determined the period of the fork, it is only necessary to stop the pendulum, so as to complete the circuit permanently, and then introduce a telegraph key into the line. Now the sounder will register accurately each time the key is depressed, and the time between any two depressions may be determined by counting the number of fork vibrations included between the dots corresponding to those depressions. If for any reason it is desired to have the seconds marked also, the key for the occasional signals must be included in a

shunt on the main circuit, connecting the wire at *b*, with the wire leading to the top of the pendulum. The sounder will then register both the vibrations of the pendulum and the signals of the key.

### 3. SCALE DIVIDER.

It is often convenient in the work of a physical laboratory to have the means of quickly dividing a given distance into a specified number of parts. For instance, paper scales divided into tenths and hundredths, having a total length which bears no simple ratio to any ordinary unit of length, are occasionally required. The device shown in *Fig. 6*, Plate B, will be found useful for this purpose. It consists of a large piece of heavy card board, upon which is drawn an equilateral triangle, with a series of lines connecting the apex *a*, to points in the base *b c*, that accurately divide it into one hundred equal parts. The sides of the triangle should be about one metre long, and it is best to make the base of exactly that length. It is not necessary that the other sides should be exactly equal to each other or to the base. It is well to have lines, (not shown in the figure,) drawn parallel to the base at intervals of two centimetres, through rather more than half the height of the figure, or else a parallel ruler so fixed that it will always be parallel to the base. The edge to be divided, which must not exceed a metre in length, is pushed up from the bottom of the figure, always parallel to the base, until it exactly includes the number of divisions to be made between its ends. The points at which the lines meet the edge may then be marked with a pencil or pen, and the graduation is made. If the lines are drawn with care, divisions as small as one millimetre may be made with considerable accuracy. It is most convenient to have the cardboard mounted upon a wooden frame and hung upon the wall. A swinging arm, pivoted at *a*, with one edge straight and coinciding successively with the dividing lines as it is moved across the figure, may be used as a ruler to mark the divisions more rapidly. A fine needle firmly inserted at *a*, and a ruler constantly pressed against it at one end, may be substituted for this swinging arm.

### 4. AN ELECTRICAL COUPLE FOR PROJECTION.

The device shown in Plate B, *Fig. 5*, may be used as a lantern or porte-lumiere attachment, to illustrate several important phenomena of

the voltaic cell. It consists of a small slip of sheet zinc, one centimetre wide and six long, a similar slip of sheet copper a little longer, held by two saw cuts across the edge of a piece of thin board *a*, two c.m. wide, ten long and one thick, as shown in the figure. Two similar couples should be prepared, one with zinc amalgamated, the other without. The upper extremities of the slips should be filed flat and kept bright, so that good electrical contact can be secured between them, by simply laying a little slip of sheet copper *d*, across the tops. In use the metals are immersed in a flat cell containing dilute sulphuric acid and projected with a lantern or porte-lumiere. The following are among the points that the couple is designed to illustrate :

a. The fact that although the hydrogen is given off at the copper plate, the action is really at the surface of the zinc. This is shown very prettily by the currents of zinc sulphate solution falling from the zinc. These currents are clearly seen by virtue of their high refractive power.

b. The effect of amalgamation. This is very satisfactorily demonstrated by comparing the appearance of a couple having its zinc amalgamated with that of a couple having its zinc unamalgamated. A good idea of the relative amounts of local and useful action may be gained by comparing the rates of evolution of hydrogen at the zinc and copper plates respectively.

c. Diminished battery action with increase of external resistance. This is shown by replacing the connecting slip by a little piece of gas carbon or thin platinum wire.

d. The effect of a depolarizing substance is shown by using fresh bichromate battery solution in place of the dilute acid. The non-appearance of hydrogen and the change in color of the liquid from orange to green, are the points to be noted. If the glass cell is divided into two parts by a thin partition of plaster of paris, so that the zinc may be on one side and the copper on the other, the complete action of any two-fluid cell, as the Daniel, may be shown.

e. *Fig. 7* shows a couple in which the copper plate is fused into a small test tube so that currents may be compared quantitatively by the amounts of hydrogen which they liberate at the negative plate.

A. D. COLE.

A SPECIMEN OF *HESPEROPHONA VESPERTINA*, Bonap.

W. G. TIGHT.

On the 10th of December a specimen of this rare bird was killed in front of Academy Hall, by Mr George Osbun. The bird was a male and was apparently alone and was feeding on maple seeds, which were very abundant under the trees in front of the building. While it was busily engaged at its noon meal it kept up a constant chirp like that of the *Cardinalis virginianus* and only sounded its characteristic "yeeip" when it was disturbed and was in the trees.

As the bird is such a rarity for Ohio, having been identified but once before, as far as I can learn, (Ohio Geological Report, Vol. IV, p. 313.) in the State and that in March, 1860, I have concluded to give a detailed description of the superficial characters of the specimen in hand.

It does not differ much from the descriptions of Baird, Jordan, Coues, Wheaton, and Herrick, (Bulletin, Vol I.), which I have before me, except in the amount and distribution of white on the wings, the length of the three outer primaries being equal and a few other minor points which will be observed by comparison. For the complete osteology of the species, reference is made to the article of Prof C. L. Herrick, University of Cincinnati, in Vol. I. of the Bulletin of Denison University.

*Hesperophona vespertina* Bonap. Bird, Male. Feet short; tarsus less than middle toe; tel. .93; tra. .56; lateral toes equal; 3t. and 4t. 7; claws compressed .12; bill very large, greenish-yellow (not dusky at base), .75 long and .75 deep; gape .81; tip of upper mandible extending beyond and over the lower; body length 8.10; wing 4.25; tail 2.50; depth of tail notch .25; primaries much longer than secondaries, the outer three equal and extending to beyond the middle of the tail; secondaries 6 in number and equal; tertiaries 3 in number and unequal; wing coverts covering half the extent of the wings; tail cov-

coverts covering three-fourths of the length of the tail ; nostrils covered by tufts of setaceous feathers and there is a tuft also at each side of the base of the culmen just in front of the eyes, with the setæ directed downwards and forwards. Coloration: The setæ and feathers at the base of the bill; crown; primaries; primary upper coverts; proximal half of the quills of the secondaries and tertiaries; proximal half of the quills of the inner half of the greater upper coverts; outer half of greater upper coverts; median and lesser upper coverts; twelve rectrices; upper tail coverts; and tibia black. From the black of the head the color shades rapidly into a deep brown and this to olive brown. The shading becomes more olive and finally a bright yellow on the rump and the under tail coverts. A broad band across the forehead and over the eyes; all the under wing coverts bright yellow. The distal half of the quills of the secondaries and tertiaries; distal half of the quills of the inner half of the greater upper coverts, white; with the outer margins of all the white portions of these feathers lined with a fine bright yellow margin.

It is interesting to notice how the white is distributed on the wings so as to make the greatest show with the least amount of white. The distal ends of the quills of the secondaries and tertiaries being white just to where the upper coverts begin and the distal ends of the greater coverts, being white just to where the median coverts begin, while the proximal ends of the white feathers which are covered are black. This combination of black, brown, olive, yellow and white makes a very beautiful effect. In the description, terms and abbreviations are after Coues, and measurements are in inches.

In connection with the appearance of this northern visitor it is worthy of notice that the winter has been unusually warm, vegetation just on the point of germination.





## IV.

### COMMUNICATIONS.

#### I. THE WAVERLY GROUP.

W. F. COOPER.

In continuing the list of articles on the Waverly of Ohio, under the direction of Prof. Herrick, the writer has endeavored to make the work as complete as possible, and it is hoped that the following pages may throw some light on the relation of the different horizons of the Waverly as exposed in Central and Northern Ohio. The identification of horizons has been made on organic evidence alone, except when conglomerates I and II were exposed, when it would be impossible to misconstrue the relations. As has been stated, the object of the survey was to ascertain the relation of the different subdivisions of the Waverly in Central and Northern Ohio. With that end in view, sections were made in most of the counties in this formation from the southern part of Ashland County to Cuyahoga Falls, Summit County. Over considerable areas it was impossible to trace the transition owing to the lack of high vertical sections, but most of the main facts illustrating the sequence were discovered.

In giving the results, we desire to acknowledge indebtedness to Prof. Pike of Garrettsville, Portage County, and Mr. J. E. Woodland of Wooster, for valuable information respecting localities. Before giv- —

ing the results it may be convenient to give a brief synopsis of the horizons as represented in Central Ohio.

|                            |           |          |       |
|----------------------------|-----------|----------|-------|
| Sandy shales and freestone | - - - - - | 30 ft.   | III3. |
| Shales and freestone       | - - - - - | 100 ft.  | III2. |
| Shale                      | - - - - - | 5 ft.    | III1. |
| CONGLOMERATE II            |           |          |       |
| Shale                      | - - - - - | 7 ft.    | II2.  |
| Freestone                  | - - - - - | 40 ft.   | II1.  |
| CONGLOMERATE I             |           |          |       |
| Shales                     | - - - - - | 60 ft.   | I5.   |
| Shales, concretionary      | - - - - - | 30 ft.   | I4.   |
| Lower Berea Shales         | - - - - - | 180 ft.? | I3.   |
| Berea grit &c.             | - - - - - | 100 ft.? | I2.   |
| Bedford shale              | - - - - - | 40 ft.   | I1.   |

As may be seen by this section, the strata are divided into three portions, the first lying below the Chester limestone in Fairfield Connty, but farther north under the Carboniferous conglomerate, the second portion lying between conglomerates I and II, while division I rests on the Huron shale in Franklin County, but in Cuyahoga County, the Cleveland and Erie shales are interposed. For a correct understanding of the relations of the divisions farther north, it will be necessary to give a brief summary of the subdivisions as represented in Licking County. The Bedford shale (I1) is well exposed at Central College, Franklin County, where it lies immediately upon the Huron shale. It is of a chocolate color and can be easily traced on account of that lithological peculiarity. Five feet above the base, the following characteristic species were found, *Macrodon hamiltonae*, *Leda diversa* and *Orthis vanuxemi*. Lying on this is the Berea grit (I2) which may be one hundred feet thick but absence of exposures renders it very uncertain. Next in order is the Lower Berea shale (I3).

The stratigraphical relations of this portion of the Waverly have not been made out, but it may be 180 feet thick. Two fossiliferous layers are contained within this subdivision as far as known, the first being well exposed on Rocky Fork, three miles from Gahana, Franklin County. Only two species were obtained here, viz: *Orbiculoidea newberryi* and *Lingula melie*, which are very abundant at a considerable distance above this. In the same subdivision is another fossiliferous zone from which many specimens may be obtained by a patient collector. *Atrypa reticularis*, *Strophomena rhomboidalis* and *Prætus haldemanni*, with several other species, are found in this stratum. Resting on the

Lower Berea shale is the Upper Berea shale (I4), which is the most fossiliferous zone yet found in the Waverly of Central Ohio; it is well exposed at Moots' Run, Licking County, where over seventy species have been found; it is an excellent base to work from, as it extends from the Ohio river to Lodi, Medina County. Lying on this, and forming the top of division I, is the Waverly shale; the fauna of this portion is remarkable for not containing more than ten species of gastropods and brachiopods among the thirty-five species which have been described from it. The typical locality for this subdivision is the quarry on Raccoon creek, near the Dugway, three miles west of Newark, Ohio. At the close of this period conglomerate I was deposited, which also inaugurated division II. This division is separable into two distinct portions. Subdivision II1, is the freestone from which most of the rock for building purposes is obtained; *Syringotheris carteri* and *Crenipeden winchelli* are characteristic species. Above this, and underlying conglomerate II, is a band of shale (II2) seven feet thick. *Allorisma winchelli* and *Sanguinolites obliquus* are characteristic species of this layer. At the close of division II, conglomerate II was deposited, the conditions attending the deposition of which were subject to fewer breaks than those accompanying conglomerate I, as shown by the fact that some of the fossils of II2 occur also in conglomerate II, and even somewhat higher, while conglomerate I contains not a single lamellibranch or other remains, except a few brachiopods. Division III is separated into three portions, the first being well exposed at a quarry one and one-half miles south of Newark, Ohio, where it is five feet thick and is easily identified by means of the conglomerate which underlies it. *Orbiculoides pleurites* and *Allorisma consanguinatus* are characteristic species. The second part of division three (III2) is well exposed at the water works reservoir one mile north of Newark. It is here one hundred feet thick. *S. stiratiformis* and *Schizodus newarkensis* are characteristic fossils. Resting upon this and forming the top of the Waverly formation is about 25 feet of sandstone containing *Phillipsia serraticaudata*, *Spirifer kookuk*, and *Productus rushvillensis*, with several other forms peculiar to it. The theory advanced by Prof. Herrick, for the origin of these conglomerates and the different faunal representations accompanying them, is, that there were a series of oscillations greatest in Central Ohio and lessening in intensity as we go north. When the first upheaval took place the central Waverly area was raised up and conglomerate I was deposited, resulting in the

destruction of almost all the life. Again there was a submergence and the freestone of division II was deposited. In course of time conglomerate II was laid in the same way as conglomerate I had been, then the Waverly sea had a long period of rest during which over 130 feet of sediment was deposited. It is the object of this paper to show how the different horizons were affected by such oscillations, and if the strata in the northern part of the state cannot be most satisfactorily correlated on such an hypothesis. For convenience of comparison the same numbers for the different subdivisions will be used as are given in the first section. The following section taken from Bulletin Vol. IV of Denison University, will give a correct idea of the strata as represented in Hanover Township, Ashland County :

|                                            |   |   |   |         |                   |
|--------------------------------------------|---|---|---|---------|-------------------|
| Shales, <i>Phillipsia serraticaudata</i> , | - | - | - | 20 ft.  | III <sub>3</sub>  |
| Freestone and shale,                       | - | - | - | 100 ft. | III <sub>2</sub>  |
| CONGLOMERATE II,                           | - | - | - | 3 ft.   |                   |
| Shale, <i>Sanguinolites obliquus</i> ,     | - | - | - | 5 ft.   | II <sub>2</sub> . |
| Freestone.                                 | - | - | - | 27 ft.  | II <sub>1</sub> . |
| CONGLOMERATE I,                            | - | - | - | 18 ft.  |                   |
| Waverly shale,                             | - | - | - | 40 ft.  | I <sub>5</sub> .  |
| Concretionary shales,                      | - | - | - | 30 ft.  | I <sub>4</sub> .  |

As can be seen the portion above conglomerate I has undergone scarcely any change, but a few facts observed are perhaps worthy of notice. The part designated III<sub>2</sub> is not as fossiliferous as at Newark, Ohio, although the different species are represented and occupy the same place as farther south. The layer above conglomerate II has almost entirely lost its lithological character and fauna, *Orbiculoidea pleurites* being the only species found that could be referred to III<sub>1</sub>, with that also occurs *Discina magnifica*, which is described beyond, some specimens of which measure  $2\frac{1}{8}$  inches in length. *Syringotheris carteri* is also found in this stratum, as that species occurs very rarely above conglomerate II in Licking County. It would seem to indicate that the barriers which held most of the species very closely in Central Ohio, were beginning to disappear. This, however, cannot be substantiated on stratigraphical grounds, as conglomerate II is as thick here as in Granville Township. The freestone or II<sub>1</sub> of Licking County is almost ten feet less in thickness than farther south, and is not as fossiliferous as in Licking County. In the Waverly shale (I<sub>5</sub>) no species have been found which could be referred to its equivalent farther south, but its position between the nodule layer and conglom-

erate I is sufficient to indicate its presence. The nodule layer is well exposed here and is rather fossiliferous, at the same time, some of its species which are characteristic of that horizon in Licking County, do not occur here, and vice versa. It may be well to illustrate this point more clearly. At Moots' Run the characteristic species are *Spirifer marionensis*, *Phillipsia præcursor*, *Streblopteria fragilis* and *Pterinopecten cariniferus*, in Ashland County, Hanover Township. *Phillipsia præcursor* and several other more uncommon forms have disappeared and some new species have taken their place, as *Pterinopecten ashlandensis*, and *Leiorhynchus ? richlandensis*, while *Hemipronites cenistria* and *Spirifer ? tenuispinatis*, which are scarce at Moots' Run, are very abundant here. The concretionary zone is about 250 feet below the Carboniferous conglomerate in Licking County, while in Ashland County it is only 200 feet. At Wooster, Ohio, the following section was obtained along Christmas Run and in Reddigs Quarry, immediately north of the city.

|                      |   |   |   |   |   |        |       |
|----------------------|---|---|---|---|---|--------|-------|
| Dark sandstone,      | - | - | - | - | - | 15 ft. | III2. |
| CONGLOMERATE II,     | - | - | - | - | - | 18 in. |       |
| Freestone,           | - | - | - | - | - | 40 ft. | II1.  |
| CONGLOMERATE I,      | - | - | - | - | - | 1 ft.  |       |
| Shales, &c.,         | - | - | - | - | - | 30 ft. | I5.   |
| Concretionary shale, | - | - | - | - | - | 30 ft. | I4.   |

The strata lying on top of conglomerate II are not very well exposed, but one species (*Discina magnifica*) which occurs in III1, in Hanover township, is found immediately over conglomerate II1. It would be impossible to draw any line between III1, and III2, so that the former will be considered a part of III2. The top of division two or II2, which is exposed in Ashland county, has no equivalent here, and II1 is sparingly fossiliferous. *Lyringotheris carteri*, which is so abundant farther south, was not found at this place. The nodule layer can be very easily correlated with its equivalent in Ashland County, but bears the same relation to that outcrop as exists between the first two exposures mentioned. Our collections seem to indicate that *Pterinopecten ashlandensis* and *Athyris ashlandensis* have disappeared, while *Pterinopecten cariniferus* and *Lyriopecten nodocostatus* are very rare. *Spirifer marionensis*, *Mytilarca fibristriatus*, and *Poissidomya*

*fragilis* occur both here and in Licking County, while *Cyrtinia acutirostris*, which is found at Lodi, Medina County, rarely occurs here.

|                   |   |   |   |   |   |        |        |
|-------------------|---|---|---|---|---|--------|--------|
| Coarse sandstone, | - | - | - | - | - | 10 ft. | III 2. |
| CONGLOMERATE II,  | - | - | - | - | - | 5 ft.  |        |
| Sandstone,        | - | - | - | - | - | 12 ft. | II. 1  |

Four and one-half miles northwest of Wooster, the above section was obtained in a quarry. No fossils which could with certainty be referred to the strata farther south, were found here, but it is hardly possible that the conglomerate exposed can be conglomerate I, as the stratum below it is a solid freestone, containing *Chonetes*, while that below conglomerate I is usually a shale and no specimens belonging to the genus just referred to have ever been found immediately under conglomerate I. We should hardly expect conglomerate II to be so much thicker here than at Wooster; it must therefore be a local development, as it thins entirely out farther north. A few plants were found in it which is a new feature. The strata underlying the conglomerate show premonitory symptoms of the decline farther north

|                 |   |   |   |   |   |        |       |
|-----------------|---|---|---|---|---|--------|-------|
| Freestone,      | - | - | - | - | - | 20 ft. | II 1. |
| CONGLOMERATE I, | - | - | - | - | - | 3 ft.  |       |
| Blue shale,     | - | - | - | - | - | 30 ft. | I 5.  |

In this section which is exposed in Funk's Hollow, five miles northwest of Wooster, conglomerate II is not represented, the top of division II having been removed by erosion; in II 1 *Syringotheris carteri*, *Sanguinolites aeolus*?, and *Phaethonides occidentalis* were found. These in Licking County are confined to division two. Conglomerate I is underlaid by thirty feet of blue shale which is entirely unlike its equivalent farther south. The nodule layer is not exposed.

|                                      |   |   |   |   |   |        |        |
|--------------------------------------|---|---|---|---|---|--------|--------|
| Sandstone and shales,                | - | - | - | - | - | 60 ft. | III 2. |
| CONGLOMERATE II,                     | - | - | - | - | - |        |        |
| Loosely bedded sandstone and shales, | - | - | - | - | - | 15 ft. | II.    |

This section is revealed on the east and west banks of the Killbuck, eleven miles north of Wooster. The sixty feet of strata forming the top of the section, consist of alternating shales and beds of white sandstone, which are quarried in places. No fossils were found in this part of the section. Underlying this is about fifteen feet of sandstone and differs lithologically from its equivalent at Wooster. It contains poorly preserved casts of *Rynchonellae*. The position of

conglomerate II, which has thinned out, is approximately indicated by the presence of *Allorisma winchelli*.

|                     |   |   |   |   |   |                           |
|---------------------|---|---|---|---|---|---------------------------|
| White sandstone,    | - | - | - | - | - | 20 ft. III <sub>2</sub> . |
| Blue shale,         | - | - | - | - | - | 35 ft. III <sub>2</sub> . |
| { Sandstone,        | - | - | - | - | - | III <sub>2</sub> .        |
| { Sandstone,        | - | - | - | - | - | 30 ft. II <sub>1</sub> .  |
| Concretionary zone, | - | - | - | - | - | 10 ft. I <sub>4</sub> .   |

Ascending the Killbuck a short distance we find along Shade Creek, which empties into the Killbuck from the west the above section. About twenty feet of white sandstone containing *Schizodus newarkensis* ? and an undetermined species of *Orthis* forms the top of the section. The blue shale underlying it, is better exposed here than in the section last mentioned and contains numerous fucoids. The thirty feet of sandstone overlying the concretionary zone contains *Productus semireticulatus* (which only occurs in II<sub>1</sub> and III<sub>2</sub> in Central Ohio.) Whether these flags belong to II<sub>1</sub> or III<sub>2</sub>, is doubtful, as no line can be drawn between them on any organic evidence. It seems probable, however, that the lower portion belongs to II<sub>1</sub>, as fossils occupying that height occur farther north. The Waverly shale has thinned out at this locality. The concretionary zone is represented by *Syrinopten nodocostatus*, *Chonetes tumidas* and *Pterinopecten cariniferus*. About one mile from where Shade Creek empties into the Killbuck, and four and one-half miles south of Burbank, in a ditch by the road side, *Spirifer biplicatus* and *Productus duplicostatus* were found, both of these species occur in the middle part of division III in Licking County, as they are found on the same altitude as the upper part of the sandstone overlying the concretionary zone in Shade Creek. it would seem to indicate that the upper part belongs to that period. The lithological features are however entirely different from the flags at Shade Creek, and resemble the exposure at Burbank, Ohio. Two miles south of Burbank and a little below the last exposure, *Sanguinolites naiadiformis* and *Edmondia tapesiformis* were found. The former species occurs in II<sub>1</sub> in Licking County, while the second was described by Meek, from Richfield, Summit County, it has not been found in Central Ohio. On the Killbuck, a short distance southwest of Burbank, occurs the Cuyahoga shale of the Ohio geologists. This horizon would include the stratum last mentioned. At Burbank, *Spirifer biplicatus*, *Productus newberryi* and *Hemipronites cenistria* are the



characteristic species. At Lodi, Medina County, occurs thirty feet of argillaceous shale full of concretions, and in it are found four species which occur at Moots' Run, Licking County, viz: *Fenestella herrickana*, *Rhombopora ohioensis*, *Pterinopecten cariniferus*, and *Terebratula ? inconstans*, while *Cyrtinia acutirostris* which occurs in the nodule layer at Wooster is also collected here. This stratum is about 125 feet below the carboniferous conglomerate. It would thus seem that although the fauna at Lodi differs considerably from that of Moots' Run, the difference could be accounted for, by the gradual disappearance of species and new forms taking their place. We would correlate the Cuyahoga shale with its equivalents farther south in the same manner as the concretionary zone, as there is no reason to think that the Waverly strata, which were deposited subsequently, did not sustain the same relation to each other as when the concretionary stratum was deposited. The Cuyahoga shale, however, seems to have included elements above any of its equivalents in Central Ohio. For example, *Entolium aviculatum* and several species of *Aviculopecten*, which have affinities with coal measure forms. The different physical conditions under which the Cuyahoga shale was deposited necessarily brought in new forms, as *Allorisma cuyahoga*, *Entolium aviculatum*, *Solenomya cuyahogaensis*, and *Macrodon tennistriata*, and several other species which are not found farther south. It has also some species which occur in the Waverly of Central Ohio, viz: *Nucula houghtoni*, which has a range from thirty-five feet below conglomerate I to five feet above conglomerate II, *Spirifer biplicatus*, which is found in the middle part of division III, *Conularia newberryi*, which ranges from III<sub>1</sub> to III<sub>2</sub>, and *Pleurotomaria stella*, which is found in III<sub>1</sub>. These species will serve to illustrate the composite nature of the Waverly as represented in the Cuyahoga valley at and above the Big Falls.

It has been suggested in volume IV, page 103, of the Bulletin of Denison University, and in Vol. VI, page 37, of the Ohio Geological Survey, that the Cuyahoga shale as exposed in the valley of the Cuyahoga, should be separated on account of lithological and palaeontological differences existing between the different portions of the series as exposed in that locality. We will now describe the strata there, giving their equivalents as represented in Central Ohio as nearly as possible. It must be remembered, however, that the three subdivisions into which the series have been divided, blend into each other so that no line can be drawn separating them. Extending from the Big

Falls, 80 feet below the carboniferous conglomerate to that layer, we find a series of shales, &c., generally unfossiliferous, but containing two horizons, from which many species have been obtained. The first horizon, from which over thirty-five species have been figured in Bulletin Vol. IV, of Denison University, is forty feet below the carboniferous conglomerate, the second is exposed in the series of shales and free-stones of which the stratum forming the Big Falls is the top. *Allorisma cuyahoga* and a species of *Chonetes* are the only species thus far obtained from that horizon. These zones are probably equivalent to divisions II and III of Licking County. We have seen that the Waverly shale, disappears at Shade Creek, north of Wooster, and consequently we should not expect to see it here. The concretionary zone (I<sub>4</sub>) has lost its lithological character here and has probably thinned out. Judging from the relative position it holds at Richfield its horizon would be under the Big Falls. More collecting will have to be done before anything definite can be said as to its position here. The Berea shale, which extends almost to the Big Falls, is very different, both lithologically and palaeontologically from the Cuyahoga shale proper. Five species have been obtained in this portion of the series, which are illustrated in Volume IV, Bulletin of Denison University, Plate X, Figs. 29, 30, 31, 32, 33. It will be seen by referring to that plate, that the portion above the falls has nothing in common with this shale, which is equivalent to a portion of division I<sub>3</sub>. The Berea grit and Bedford shale are respectively equivalent to I<sub>2</sub> and I<sub>1</sub> of Licking County.

# TABULATED LIST OF FOSSILS KNOWN TO OCCUR IN THE WAVERLY OF OHIO.

Additions and corrections to the list published in Volume IV, page 123.

W. F. COOPER.

For the additions and corrections to the crinoids we are indebted Mr. F. A. Bather, of the British Museum, London. The corrections adapt the list to the nomenclature of Wachmuth and Springer.

## CRINOIDEA.

|                            |                                   |
|----------------------------|-----------------------------------|
| For Actinocrinus helice,   | <i>read</i> Agaricocrinus helice. |
| " " viminalis,             | " Amphorocrinus viminalis.        |
| " Forbesiocrinus communis, | <i>read</i> Taxocrinus communis.  |
| " " lobatus,               | " " lobatus.                      |
| " " kellogi,               | " " kelloggi.                     |
| " Poteriocrinus crineus,   | " Scaphiocrinus crineus.          |
| " " corycea,               | " " corycea.                      |
| " " pleias,                | " Decadocrinus pleias.            |
| " Scaphiocrinus lyrioepes, | " " lyrioepes.                    |
| " " subtortuosus,          | " " subtortuosus.                 |
| " Zeocrinus paternus,      | " Woodocrinus paternus.           |
| " " meriope,               | " " meriope.                      |
| " Scaphiocrinus algini,    | " Decadocrinus aegina.            |

## ADDITIONS.

Taxocrinus lobatus, var. tardus.  
 Platycrinus bedfordensis, Hall and Whitfield, O. Pal. Vol. II, p.  
 - Erie shale.  
 Platycrinus lodensis, Hall and Whitfield, Id. p. 168.  
 Woodocrinus richfieldensis, Worthen, Bull. I, Ill. State Mus. Nat.  
 it. p. 15.  
 Agaricocrinus eris is a variety of A. helice.

Falls, 80 feet below the carboniferous conglomerate to that layer, we find a series of shales, &c., generally unfossiliferous, but containing two horizons, from which many species have been obtained. The first horizon, from which over thirty-five species have been figured in Bulletin Vol. IV, of Denison University, is forty feet below the carboniferous conglomerate, the second is exposed in the series of shales and free-stones of which the stratum forming the Big Falls is the top. *Allorisma cuyahoga* and a species of *Chonetes* are the only species thus far obtained from that horizon. These zones are probably equivalent to divisions II and III of Licking County. We have seen that the Waverly shale, disappears at Shade Creek, north of Wooster, and consequently we should not expect to see it here. The concretionary zone (I<sub>4</sub>) has lost its lithological character here and has probably thinned out. Judging from the relative position it holds at Richfield its horizon would be under the Big Falls. More collecting will have to be done before anything definite can be said as to its position here. The Berea shale, which extends almost to the Big Falls, is very different, both lithologically and palaeontologically from the Cuyahoga shale proper. Five species have been obtained in this portion of the series, which are illustrated in Volume IV, Bulletin of Denison University, Plate X, Figs. 29, 30, 31, 32, 33. It will be seen by referring to that plate, that the portion above the falls has nothing in common with this shale, which is equivalent to a portion of division I<sub>3</sub>. The Berea grit and Bedford shale are respectively equivalent to I<sub>2</sub> and I<sub>1</sub> of Licking County.

## 2. TABULATED LIST OF FOSSILS KNOWN TO OCCUR IN THE WAVERLY OF OHIO.

Additions and corrections to the list published in Volume IV, page 123.

W. F. COOPER.

For the additions and corrections to the crinoids we are indebted to Mr. F. A. Bather, of the British Museum, London. The corrections adapt the list to the nomenclature of Wachsmuth and Springer.

### CRINOIDEA

|                            |                                   |
|----------------------------|-----------------------------------|
| For Actinocrinus helice.   | <i>read</i> Agaricocrinus helice. |
| " " viminalis.             | " Amphoraocrinus viminalis.       |
| " Forbesiocrinus communis. | <i>read</i> Taxocrinus communis.  |
| " " lobatus.               | " " lobatus.                      |
| " " kellogi.               | " " kellogi.                      |
| " Poteriocrinus crineus.   | " Scaphiocrinus crineus.          |
| " " -----                  | " " -----                         |

## LAMELLIBRANCHIATA.

- Cypricardinia consimilis, Hall.  
Edmondia ellipsis, Hall.  
Elymella patula, Hall.  
Macrodon ovatus, Hall.  
Nuculana pandoriformis, Stevens.  
Palæaneilo truncata, Hall.  
Pararca erecta, Hall.  
Pterinopecten shumardanus. Pterinopecten shumardanus.  
Schizodus (chemungensis var.) prolongatus. Hall.  
“ aequalis, Hall.  
Sphenotus æolus, Hall.  
“ flavius, Hall.  
“ valvulus, Hall.  
“ signatus, Hall.

## BRACHIOPODA.

- Syringothyris typa, Win.  
Lingula cuyahogensis, Hall.  
“ subspatulata, M. and W.  
Productus cooperensis, Swallow.  
Strophomena rhomboidalis, Wilchins.

## CRUSTACEA.

- Paoetus haldemani ? Herrick.

## GASTEROPODA.

- Flemingia ? stulta, Herrick.  
Pleurotomaria strigillata, Herrick.

### 3. THE CENTRAL NERVOUS SYSTEM OF RODENTS.

(Preliminary Paper )

Read by abstract before the Denison Scientific Association, April 5th, 1890.]

C. L. HERRICK AND W. G. TIGHT.

The following notes upon the central nervous system of *Arctomys* are intended simply as an introduction to the more detailed work which is hoped to devote to the nervous anatomy of the rodents. While much has already been done in the examination of other types and the effort has been made to homologize the structures described with those of other orders of mammals, only a few disconnected references to such results of our work can be well introduced. The publication of an incomplete installment of the paper seems advisable, because of the large number of figures which will be necessary to fully carry out the undertaking. These drawings being faithful photographic copies of sketches made by the aid of the camera lucida, are relied upon to give our notes a certain value even in their incomplete and imperfect state.

The several paragraphs having been written by different hands and even without opportunity for consultation, it is obvious that disparity of style and diversity in treatment may be expected. The responsibility, therefore, is a mixed one, and it will not be possible or necessary to unravel it entirely; the drawings, however, are accredited to the authors respectively, and from the references to these the source of most of the statements may be gathered.

In the present conflicting condition of neurological literature the earliest contribution of exact data upon the minute structure of the brain should be welcome, and the most hopeful field for the solution



of the perplexing problem lies in work upon the simpler types. The subject chosen possesses several advantages. It is a primitive representative of the sciurormorphs or squirrel-like rodents, having simply organized cerebrum and yet a greater exposed cortex than the myomorphs which, at first thought, might have been preferred. The brain is large enough for localization experiments, but small enough for continuous sections through at least one-half of the brain. Another incidental advantage is that the type is one whose cerebral anatomy has not been exhaustively treated. The resemblance in many respects is close to the brain of the hare, and we have data derived from the latter subject sufficient to serve as a guide in the present case. During the progress of the work the desirability of comparison with the brains of even lower types of structure became so obvious that resort was taken to the alligator and Amphibia, the results of a brief study of the former being embodied in a paper by one of us, in the current volume of the *Journal of the Cincinnati Society of Natural History*. A similar study of the brain of the opossum, being now in progress, may be shortly expected.

Inasmuch, however, as the work upon the ground hog has been so long under way and some of the results have already been published, it has been thought best to present it as it now stands as introductory to the more detailed anatomy of other rodent types.

A word regarding the method followed may be appropriate:

The subject chosen was the ground hog, *Arctomys monax*, while the brains of rabbits, opossums, and raccoons served for comparison. The functions of the cortex were investigated by electrical stimulation and extirpation. In this way the motor centers for the fore and hind legs, the muscles of the face and neck, and the sensory areas were accurately diagramed. A method used by us for the first time may be incidentally mentioned as worthy of more careful employment. As the electrodes were removed from the brain a small pasteboard or wooden peg bearing a number, was inserted and the reaction produced at this point was carefully recorded upon a diagram of the surface of the hemisphere with the corresponding number attached. After the removal of the brain these tags served to check the accuracy of the diagram, and a careful drawing was made including the areas experimented on.

The brains were placed in chromic solution twenty-four hours and then in alcohol, and continuous series of sections taken in various direc-

tions mounted in balsam. Several hundred such sections were prepared and studied by the method of geometric reconstruction from camera drawings and measurements.

The chrom-acetic solution appears to us to have decided advantages over any other fluid used. For some brains it should be considerably more dilute than the standard advised by Fol. The most generally satisfactory stain is aqueous hæmatoxylin with the possible exception of a new stain, an account of which is at present reserved. Alum-cochineal ranks next and, although it does not preserve the fine histological details and causes a shrinking of cells and delicate organs generally, it has the great advantage of being adapted for the staining of fragments in toto, thus enabling one to fix the sections upon the slide at once, obviating the danger of loss as well as avoiding the great labor involved in the usual hæmatoxylin method. The ordinary carmine stains are relatively useless as are the alcohol solutions of hæmatoxylin, etc.

Analine blue-black has many of the good properties of hæmatoxylin but seems less desirable on the whole. A solution of methyl blue in oil of cloves promised well, but it was found impracticable in actual practice. So far as our experiments went the mingling of stains with Mueller's fluid proved unsatisfactory.

In some cases alum-cochineal serves to differentiate the fibre tracts very perfectly, but those preparations are less perfect respecting the cells. In fact no reagent was found serving both purposes equally. We have preferred, therefore, the use of a reagent which alters the natural relations as little as possible and permits the tracing of what may be confidently regarded as the normal connections albeit at great expense of patience and time. Successfully stained hæmatoxylin preparations do this. The various methods of staining fibres only, although undoubtedly of the highest value, do not prove adapted for the minuter work of tracing cells in their mutual relations. Ours has been the common fate. It has not infrequently happened that the same process applied to two entirely similar brains has resulted in failure in one case and success in another. Thus far no infallible technique has been discovered. The statements made on the basis of the few specimens studied must remain open to the criticism of subsequent study.

Previous to the sectioning, as already said, several localization experiments were made both by electrical stimulation and extirpation. The first specimen was a male of *Arctomys monax*, the same specimen which

furnished the sections most frequently described and figured beyond. Ether was employed as an anesthetic, and the skin was parted down the median line of the head and the skull removed over the anterior and middle parts of the left hemisphere. The current used was from one Grove cell and was just enough to operate the induction-coil, producing an irritation easily endured by the tongue. When the electrodes were introduced at *a*, Fig. 4, Plate V, (at about the anterior one-third, near the median line and corresponding approximately to Munk's region C of the dog) a forward and outward motion of the right fore leg was produced. A stronger current produced an electrotonic contraction of the muscles of the whole right side. At the point *b*, about 5 mm. behind and a little outward from the above (corresponding to about the posterior margin of Munk's region D), the stimulus produced a straightening of the right hind leg. At the point *c*, about 8 mm. behind *b*, and near the median fissure (corresponding to about Munk's region F, near the median line), the stimulation resulted in a sharp contraction of the orbicularis palpebrarum and orbicularis oris of the right side and some feeble contraction of the facial muscles of the left side, probably due to superficial irradiation.

At the point *d*, about 8 mm. behind *c*, and farther from the median fissure, (corresponding to the anterior margin of Munk's region A,) the insertion of the electrodes produces no motor disturbances nor did any point back of *d*. By a series of trials it was found that the electrodes produced some motor disturbance of the fore leg at all points within the area marked A, but not beyond it.

The area B likewise marks about the limits of the hind leg region. An area of about 5 sq. mm. was then removed from the cortex of the left side in the fore leg region at about *a*. The wound was then dressed and the animal allowed to recover. The power of abduction of the right fore leg was lost. After some time another portion of the cortex was removed, a little back of *d*, on the left side. After recovery it was found that the animal was blind in the right eye. These experiments serve to locate some of the motor and sensory regions of the cerebral cortex for the subsequent histological works.

It may be of interest to note also one of the series of experiments of electrical stimulation upon the Raccoon, *Procyon lotor*, which has been employed for comparative study. The animal was a male about three-fourths grown. Just enough current was used to drive the coil. Ether and chloroform mixed were the anesthetics employed.

Nearly the whole upper surface of the cerebral hemisphere of the left side was exposed. The loss of blood was very moderate.

The electrodes were introduced at point 1, *Fig. 2*, Plate XI, about 9 mm. from the median fissure and a little in advance of the line passing through the anterior angle of the eye. The result was a forward and inward motion of the right fore leg.

At point 2, the introduction of the electrode gave an undefined movement of right fore leg.

At point 3, about 7 mm. from the median line and separated from 1 by a faint sulcus, the stimulation produced a flexion of the pes on the crus and elevation of right hind leg.

At 4, a movement of the right hind leg, as at 3, and a slight rotation of the fore leg inwards.

At 5, about 3 mm. from the median line, the stimulation produced an extension and divarication of the digits of the right foot.

At 6, the fore leg was elevated and flexed, and with a little stronger current the hind leg was also elevated and flexed.

At 7, there was an extension of the toes corresponding to the movements produced at 5, of the opposite side.

Perhaps more important in its bearing on the present subject is a set of experiments upon the opossum, of which, unfortunately, no very exact data have been preserved. The configuration of the hemispheres as well as the details of structure resemble very closely those of rodents. Moreover, such hints as we have of the development of the Rodentia indicate a common origin for the two groups and comparatively slight subsequent differentiation. It, then, would not be surprising if a considerable similarity of distribution in the cortical elements should be proven to exist. On the other hand, the existence of an apparent homologue of the crucial sulcus near the front of the cerebrum would lead one to expect the aggregation of the motor elements near this sulcus. The experiments in this case were made with a Grenet cell and DuBois-Raymond coil, with the secondary coil at about 8 cm., the current being applied by a pair of platinum electrodes separated by about 3 mm. Stimulation of the region about the crucial sulcus (so called) resulted in movements of the anterior extremity, but the difficulty in controlling the flow of blood interfered with close analysis. The area on either side of the median fissure responded with various poorly localized contractions of the trunk. About 6-8 mm. posterior to the crucial sulcus and 4-5 mm. from the medial line is an ill-defined

area governing the hind leg. These motor reactions were, in the main, crossed as usual, but in several instances similar motions of the muscles of both sides resulted when superficial irradiation appeared to be excluded. The areas thus roughly mapped in the opossum coincide in general with those of the ground hog and we are forced to conclude that the crucial sulcus of the opossum is not strictly homologous with the fissure so named in carnivora.

The rodent brain is especially noteworthy because of the reptilian simplicity of structure. The smooth, depressed and elongate hemispheres, protruding and exposed olfactory lobes, and partially exposed optic lobes are such characters. The large, highly convoluted cerebellum redeems the mammalian habitus of the brain. The convolutions have definite patterns which may be of generic or possibly ordinal character. The extended flocculus is a rodent character. The forward extension of the chiasm and the great obliquity of the optic tracts, as well as the distinctness of the thalamus from the axial portion of the hemisphere may be regarded as primitive or degraded conditions as are the relatively posterior position of the corpus callosum, the distinctness of the fornix and its relation to the hippocampus and the great size of the ventricles. In spite of the considerable size of the cerebellum, it does not entirely cover the fourth ventricle. The several spinal nerves have a degree of independence greatly facilitating their study.

The comparison with the opossum on the one hand and Carnivora on the other is instructive as illustrating the range of variation in structures essentially similar. The most marked difference between the rodents and marsupials consists in the relative importance of the two great commissural systems of the fore-brain.

In *Didelphys* the callosum is practically absent and the fibres serving the function of the corpus callosum in higher mammals are associated with the anterior commissure. The structure of this region in the opossum is of great interest. The great mass of transverse fibres constituting the commissural system of the fore-brain consists of four elements, viz :

- 1st. Fibres from the olfactory tract which cross from the pyriform lobe to the thalamus near the brain base and ascend to the level of the lower surface of the anterior commissure, where they turn abruptly cephalad and decussate as they mingle with that commissure.
- 2d. the fibres of the anterior commissure itself, which, as already suggested,



gathers fibres from the cephalad as well as occipital regions at least of the ventral portions of the hemispheres. 3d, the commissure of the hippocampus is quite distinct from the previously mentioned, and is quite a narrow and slender band of considerable length, as the hippocampi, posteriorly, are oval or quadrate in section and at the point of origin of the fornix or hippocampal commissure are widely separate. 4th. A rudiment of what may be called corpus callosum, although we are unwilling to homologize it definitely with that body. The last mentioned is a small fibre-tract which lies anterior to but adherent upon the hippocampal commissure and soon loses itself in the median walls of the hemispheres corresponding to the septum pellucidum. Being a tract of the cortex this band has as great claim to be homologized with the corpus callosum as the relatively larger commissure of the alligator.

Exactly the same relations between the hippocampal commissure and the callosum are found in the insectivora, as may be seen by comparing Plate X, *Fig. 7*, except that the latter possesses a well-defined corpus callosum above the ammon's horn.

Comparing with these a section through a corresponding region of the kitten (Plate XII, *Fig. 6*), the relations appear very different, but the difference arises chiefly from the different proportions and the relative compactness of the brain whereby the thalamus and corpora striata are crowded upon each other. The wide interval between the anterior commissure and the callosum may be regarded as an incident of this consolidation. Finally, the examination of Plate X, *Fig. 5*, reveals the fact that the hippocampus has a very similar relation in the rabbit. This section, although nearly horizontal, inclines toward the median line from the cortex of the right hemisphere and embraces a segment from the middle region simply.

Before passing to a description of our own investigations, it may be well to present a summary of the results of Stieda's work upon the rabbit and rat. This summary will serve as an introduction to the subsequent paper as well.

After removing the tuber cinereum, which is but a small protuberant portion of the thalamus below, the latter appears divided by the thin cleft representing the third ventricle into two symmetrical halves. The ventricle is divided into a lower and upper portion by the adhesion of the walls, often called *commissura mollis*, which, however, is not a true commissure. The ventricle descends to the tuber cinereum.

In front of the corpora quadrigemina is a strong *posterior commissure*. The lower portion of the third ventricle pertaining to the tuber cinereum is bounded behind by the tuberculum mamillare and the substantia cinerea posteriora, in front by the thin grey lamella rising to the corpus striatum, the *lamina terminalis*.

The *copora striata* are pear shaped bodies, the anterior portions of which are connected by the *septum pellucidum*, which, in turn, is connected with the lamina terminalis. The septum is perforated by the fibres of the *commissure anterior*. The lower surface of each hemisphere is provided with a protuberance or *processus pyriformis* (in reality produced by the fold of the hippocampus) which is separated by a sulcus (*rhinalis* and *post-rhinalis*) from the remainder of the cortex. From the anterior or narrow portion of this pear shaped area extends the olfactory lobe.

Removal of successive horizontal slices of the hemispheres exposes the *callosum*, which is medianly connected by a considerable adhesion with the *cornua ammonis*. Each lateral ventricle is a cavity lying between the corpus striatum and septum pellucidum in front and between the corpus striatum and cornu ammonis below and medianly. After suitable preparation, fibres can be seen crossing below the callosum and ending in the groove between the thalamus and striatum and probably representing the posterior limb of the fornix.

*Cranial Nerves* I and II, as usual. The *oculomotor* (III) springs from the median surface of the crura, just behind the corpus mamillare. The *trochlearis* (IV) originates as a fine fibre from the horizontal part of the valvula cerebelli, immediately behind the quadrigemina. The *trigeminus* (V) arises just posterior to the pons and is composed of a lateral portio major and median portio minor. The *abducens* (VI) emerges near the median line, near the posterior margin of the pons. The *facialis* (VII) emerges obliquely from the medulla behind the pons upon the corpus trapezoidum. The *auditory* (VIII) springs from the lateral surface of the tuberculum laterale, immediately behind the *trigeminus*. The *glossopharyngeal* (IX) is a root of about three bundles springing from the lateral surface of the medulla behind the tuberculum laterale, forming a small ganglion. The *vagus* (X) consists of several bundles, forming an arch along the lateral surface of the medulla, the lowest bundle being continuous with the *accessory* (XI), fibres of which extend back as far as the third or fourth spinal nerves. The



*hypoglossus* (XII) springs, with a rather large number of fibres from the lateral margin of the pyramids.

The increase in the size of the *medulla* from behind forward is accompanied by an increase in the amount of gray matter, and also an inter-reticulation of the gray and white matter. This reticulation is the forward extension of the *formatio reticularis* of the cord. The posterior cornua are divaricated cephalad, and between them are interpolated accessory gray masses, the *corpus cuneato gracile*. The posterior part of the dorsal cornu increases in size, forming the *tuberculum Rolandii*. In the anterior (ventral) cornua the lateral giant cells disappear, but in the gray matter of the reticulum are very numerous medium and small cells. Only in the higher (cephalad) regions of the medulla do large multipolar cells (.08 mm) reappear.

In the caudal part of the medulla, near the pyramidal decussation, appear two groups of cells, the *basal* and *lateral nuclei*. The first is rather broader than the pyramids, dorsal to which it lies, and extends upward (cephalad) to about the middle of the medulla. The cells measure .016-.02 mm., with nuclei .008-.01 mm. in diameter, and have only obscure processes. This nucleus is divided into subordinate cell clusters by numerous fibres passing in all directions, which evidently have their origin here. The lateral portions of this nucleus are regularly perforated by the roots of the hypoglossus. The second group (nucleus lateralis), lies in the antero-lateral (ventro-lateral) portion of the medulla, extending a shorter distance cephalad. The cells are multipolar with angular outlines and are of median size and not closely packed. Another cell cluster, *nuclius centralis*, lies on either side of the ventricle and its cells are spindle shaped and longitudinally placed, measuring .024 mm. An additional cluster (hypoglossus nucleus), extending a shorter distance caudad and lying ventral to the above, consists of multipolar cells .04 mm. long, and retains its position near the ventricle, while the dorsal portion extends laterally toward the front. A cell clustre in the *corpus cuneato-gracile* may receive the same name and anteriorly *nucleus restiforme*. Cephalad in the medulla, after the termination of the basal nucleus, angular cells, .04 mm. in diameter collect on either side of the raphe forming the *nucleus* of the *raphe*. Cephalad from the nucleus lateralis, and distinctly separated from it, is the nucleus of the facialis, the cells of which are multipolar, with processes ascending to the root, and measure about .04 mm.

The dorsal and lateral longitudinal bundles are indistinct, but a

ventral bundle lies ventrad from the median nucleus and is bounded laterally by the hypoglossal fibres. Along the anterior surface the pyramids are very obvious. Numerous concentric fibres crossing in the raphe are also mentioned. The *fibræ arciformes* which consist of oblique fibres springing from the lateral aspect of the pyramids, curve dorsally and cephalad to the corpus restiforme, collecting there to a considerable bundle, passing cephalad, and disappearing under the tuberculum laterale.

The *hypoglossus* has two sorts of roots, some resembling in origin the roots of the anterior spinal nerves, and a bundle which springs from the nucleus above described near the sides of the fourth ventricle. There is no doubt that the nerve receives crossed fibres from the opposite side and from the longitudinal bundle.

The *accessory*. The caudal roots, *i. e.* those in the region of spinal nerves, turn abruptly to enter longitudinal bundles lying in the gray and probably arising from the anterior (ventral) cornua. The roots of the cephalad division of the accessory with those of the *glossopharyngeal* and *vagus* enter the tuberculum Rollandii, pass toward the median nuclei, but suddenly turn to form longitudinal bundles not traceable to definite nuclei. The fibres from the ventrally situated *facialis* nuclei converge dorsally, forming a considerable longitudinal bundle on either side the canalis centralis, and, turning laterally, pass, without crossing, to their exit through the longitudinal fibres of the trapezoidium.

The nucleus of the *abducens* lies lateral to the knee of the facial root, *i. e.* in its concavity. The cells of the abducens are of the same size and appearance as those of the facialis. The fibres pass ventrally and then laterally without crossing. The *acusticus* consists of the two roots, the dorsal root sends fibres to the tuberculum laterale, but a part pass beyond to the gray matter of the wall of the ventricle, where they possibly terminate in small cells. The ventral root-fibres form numerous small bundles which, after perforating the lower part of the tuberculum laterale, diverge in several directions. A small part turn abruptly dorsally to unite with the dorsal root, the remainder follow the longitudinal course of the *fibræ arciformes* to a position within the crus cerebelli, where there appears a large nucleus composed of large multipolar cells and which may be regarded as the nucleus of the acusticus.

The *trigeminus* has two roots, the larger of which is composed of

small fibres, the immediate derivatives from a longitudinal bundle appearing far caudad in the medulla and anteriorly covered by the longitudinal bundle of the fibræ arciformes. A smaller longitudinal bundle lies in the tuberculum Rolandii. The smaller root springs from a nucleus of large multipolar cells, like those of the facialis, lying below the floor of the ventricle. Its fibres curve dorsally, then ventrally and laterally to their exit. A part, however, of the trigeminus fibres can be traced to the nucleus of the trochlearis. The cells of the *trochlearis* nucleus are rounded and have few processes. The nucleus is elongate, and its fibres pass dorsally and caudad to the decussation in the valvula cerebelli.

*The Cerebellum.* The medulla is connected with the cerebellum by the fibræ arciformes, there being no connection via corpora restiform. The entire mass of the crura cerebelli ad corpora quadrigemina is derived from the cerebellum.

In the *pars peduncularis* the pyramids appear quite lateral, while the anterior longitudinal fasciculi occupy a place between them and are only separated from each other by the substantia cinerea posteriora media. In addition there is a dorsal fascicle, and isolated fibres from the cerebellum.

The gray substance between the longitudinal bundles is composed of a granular basis with small round or spindle cells and contains the following nuclei. The nucleus peduncularis consists of a lower portion composed of numerous small cells (.012-.016 mm.) and an upper smaller nucleus, with large multipolar cells (.04 mm). This nucleus occupies a lateral, ventral position below the nucleus of the *oculomotor*, which its upper portion resembles.

The corpora quadrigemina, thalami and optic region were not fully studied.

The *corpora striata* consist of mingled gray and white matter, the side nearest the ventricle being almost altogether gray, and the lateral portion united with the hemispheres is full of fibre bundles. The gray substance contains small round or fusiform cells with exceedingly fine processes and measuring .008-.012 mm.

The hemispheres are evidently zonary, the outer layer having a thickness of 0.5 mm., followed by a gray layer reposing in turn upon the inner white. The gray matter of the cortex consists of three layers of cells: first, an outer layer of small cells .008-.016 mm. long, and closely aggregated; second, the layer of large cells .04 mm. long,

which are triangular with a single peripheral process; third, small cells differing from the outer or first layer in that the cells are more spherical, while the cells of the outer layer are spindle shaped.

On the ventral surface of the callosum the cornua ammonis are connected by transverse fibres. The gray matter of the lower, or pyriform lobe fuses directly with that of the striatum, and its superficial cell-layer is composed of cells like that of the peripheral, and these are closely compacted and arranged in a tortuous line.

The septum pellucidum conforms in structure to that of the cortex. The anterior commissure consists of fibres, a part of which radiate to the striatum, and a larger part to the olfactory lobes.

The pyriform lobe, or protuberance of the ventral surface of the hemispheres, lacks the inner white, its outer cellular portion fusing directly with that of the corpus striatum.

The general description above condensed is in nearly every detail applicable to the ground hog so that it will render unnecessary any discussion of the external features. Sundry discrepancies and errors in the histological descriptions may be noted by comparison with the following pages.

A detailed special account of the gross anatomy of *Arctomys monax*, by one of us, is incorporated beyond; for the present a brief review of current views upon the questions here chiefly discussed may prove a fitting introduction to the descriptions.

With reference to the cortex the prevailing attitude is one of agnosticism, as may be inferred from the following passage from Raue:

"If the latest researches of Max Schultze are correct, it appears that the nerve cell is essentially only an enlargement, with nucleus and nucleolus, of the axis-cylinder; that, therefore, it does not represent the beginning, but is merely an intervening expansion of the nerve in its course. The bipolar cell is so to be considered. In the case of the multipolar cells of the spinal narrow, from which, according to Deiter's discovery, one axis-cylinder issues to pass toward the periphery, while many other processes spread in different directions, the cell appears to be an intermediate station for the conveyance of innumerable nerve fibrils from different regions in order to unite and form one axis-cylinder. Even here the axis cylinder cannot be considered as *originating* within the nerve cell. It is only made up there, like the bulk of a main stream, from numerous tributaries, the source of which no one has yet discovered. The researches of Deiter also made it prob-

able that the groups of ganglion cells, from which the cranial nerves arise, and which have been made known by Stilling as the nuclei of sensory roots, consist of cells in form entirely similar to those from the anterior and posterior cornua of the spinal marrow, and that they, like these, send off only one axis cylinder, which passes toward the periphery, while the other processes divide into innumerable primitive fibrils."\*

Turning to the morphological aspects of the same problem, the results are similar. Thus in the literature before 1870, although all agreed that the cortex is laminated, Baillarger (1840), Gerlach (1852), Berlin (1859), and others, described six layers, Koelliker, four to six, Arndt, five to six, and Meynert, nine. The giant pyramids or "pyramidal bodies," (Meynert), were described by Arndt as pyramids with five or more fine branches from the base, which divide dichotomously and are lost in a nervous reticulum of the ground substance, while the apex process passes upward, then abruptly turns downward to form an axis cylinder. Meynert, and after him Loechner, Kollman and Stieda, on the contrary, claim that the apical process divides, while, besides the baso-lateral processes there is a median basal double-contoured fibre which passes into an axis cylinder.

Meynert say, (*Psychiatry*, p. 70): "Betz has stated that the anterior central convolution contained groups of particularly large pyramids, which he thought were the circumscribed motor centres which Hitzig, on the strength of his physiological experiments, relegated exclusively to the anterior central convolution of the brain of dogs and monkeys. Apart from the mistake which Hitzig made in establishing the homologue in carnivora of the anterior central convolution, it has been proved that the size of the pyramids depends upon their distance from the cortical surface. The largest pyramids will, therefore, be found in the broadest cortical region; but the broadest cortical region is that of both central convolutions. \* \* \* The largest pyramids appear to be arranged in small groups at some distance from one another. It would be wrong to argue from this that these large pyramids have a different signification from the smaller ones. Luys is in a great measure responsible for this mistake. Betz appears to me not to have

---

[\* *Raue, Psychology as a Natural Science applied to the Solution of Occult Psychic Phenomena*, 1889.]



made a discovery, but to have failed to appreciate the relations which obtain in the primary disposition of the cortical elements."

The study of the cortex in animals which, like rodents, have an unconvoluted cerebrum, proves that Betz was entirely right in associating special motor areas with enlarged pyramids, as we hope to sufficiently show. The real basis for subsequent work is indicated by the following passage from Meynert:

"No morbid change and no physiological experiment gives us any reason to hope that we shall be able to explain the difference in form of cortical elements in closely neighboring layers. Morphological interpretation is the only method which can come to our rescue. The nerve corpuscles of the gray anterior horns of the spinal cord, of the central nuclei of the hypoglossal, facial and abducens nerves, and as far upwards as the oculomotor nerve, all show long, slender cell forms with numerous processes. These processes seem to arise with a broad base from the body of the cell. The same peculiarities of configuration which we observe in those nerve cells, which are connected with the centrifugal nerve tracts, are found in the cortical pyramids, and there can only be explained by the similarity in the distribution of those bodies. Gerlach has compared the median base process with those spinal cell processes which enter the anterior roots. The granules of the fourth cortical layer, which are distinguished from the free nuclei by their size and protoplasm, from the spider and spindle shaped cells by the distinct boundary of their protoplasm, and by a lesser number of stout processes, may be likened to those branched ganglionic cells which occur in centres connected with centripetally conducting tracts."—(*Meynert, Psychiatry*, p. 66.)

The paper of Golgi (*Revista sperimentale*, 1883), has remained inaccessible to us but, judging from excerpts, Koelliker's criticism (*Anat. Anzeiger*, 1888, II, No. 15,) seems justified. Especially we feel constrained to call attention to Koelliker's suggestion that the outer zone contains fibre tracts of major importance. This we had previously determined and in the case of lower vertebrates the existence of prominent tracts in the so called neuroglia layer is well demonstrated.

Koelliker says: "Sehr eigentuemlich ist, was Golgi ueber die axencylinderfortsaetze die nervenzellen mittheilt. Dieselben sollen in zwei Formen vonkommen. Bei den centrifugal-wirkenden (motorischen) Zellen soll der Fortsatz im ganzen mit gleichbleibenden Staerke zum axencylinder einem dunkelrandigen Fasser werden, ausserdem

arber auch eine gewisse Zahl feiner sich veraestelnder Fortsaetze in ein nervoesees Netz abgeben, dass nach Golgi Nervenfasern und Nervenzellen verbindet. In dieses Nets treten auszer den eben genannten feiner Auslaeufern, noch ein (1) feine veraestelte Auslaeufer der motorischen Nervenfaesern, welche von den Axencylinderfortsaetzen der motorischen Zellen entspringen, (2) Fortsaetze der centripetal erragbaren (sensiblen) Nervengellen, die Golgi als nervoese bezeichnet, arber in ein feines Netz sich aufloesen laeszt, (3) endlich veraestelte feine Auslaeufer der centripetal wirkenden (sensiblen) dunkel-randigen Fasern. Mir will es nun, trotz aller Anerkennung der wichtigen errungenschaften Golgi's, vorkommen, als ob die existenz eines solchen verwikelten nervoesen Netzes nicht hinreichend sicher begruendet sei."

The question as to the anastomoses between different ganglion cells has been laboriously argued. Some few, like Claus, Villanes, Wagner and, more recently, Nansen have denied the existence of such connections. Nansen says:

"I have on several occasions firmly denied a common existence of direct combinations between cells, not having found any case of indubitable anastomosis between cell processes." "The 'neuroglia cells' and fibres, which are interposed between the ganglion cells, have certainly assisted a great many writers to see anastomoses, as they have not understood the real nature of this supporting tissue."

The author admits what we have very frequently seen beyond doubt, that lateral communication certainly exists as a result of cell division, but seems to believe that there is a subsequent solution of continuity. He says:\*

"When one has examined so many preparations (stained by the most perfect methods) as I have, without finding one anastomosis of indubitable nature, I think one must be entitled to say, that direct anastomosis between the processes of the ganglion cells does not exist, as a rule. What previous writers have supposed to be anastomoses is, in my opinion, probably the neuroglia reticulation generally extending between ganglion cells. \* \* \* Another objection against a direct combination, and which does not seem to have been thought of by a great many authors, is the existence of unipolar cells."

---

[\*The structure and combination of the Histological Elements of the Central Nervous System, p. 846.]



Nansen agrees with Golgi in identifying two kinds of processes, nervous and protoplasmic. "Of nervous processes each cell (unipolar or multipolar) has always one and never more; the nervous processes are always directed toward the dotted substance, or in a few cases pass directly into the peripheral nerves."

The results of such a condition as this are evidently realized as revolutionary, as reference is made to the observations of Fritsch.\*

"Die apolare ganglion-cellen haben lange genug in unserer Literatur gespuht." "Eine wirklich unipolare Zelle ist fuer den Organismus nicht viel mehr werth als eine apolare Zelle." To this the present writers fully assent and furthermore find abundant evidence of the existence of two fully developed "nervous processes" in very many cells connected with the cranial nerves as well as in the cortex and feel that the ganglion cells might as well be dismissed from the ranks of servitors of cerebral function if deprived of all members but one. How the function of inhibition, for example, can construe with such a condition, does not appear.

Nansen proceeds: "When a ganglion-cell is bipolar, then the processes it possesses, besides the nervous process, are protoplasmic processes. These protoplasmic processes are not directed toward the dotted substance, but generally have a peripheral direction toward the external layers of the central nervous system." "Like Prof. Golgi, I believe the function of the protoplasmic processes to be a nutritive one; when the ganglion cells can not get sufficient nourishment in their neighborhood, they have to send processes toward the periphery of the nervous system." "Having elucidated that no combination between cells can be produced by the protoplasmic process, and as it is very improbable that any combination between them can be produced by the neuroglia, I suppose it to be most probable, if not certain, that if any combination upon the whole exists between the ganglion cells, then this combination must be produced by the nervous processes. That such a combination can exist, with the dotted substance as a medium, we can readily understand when we think of the course of the nervous processes. There may be drawn a distinction between *two types of ganglion cells* in respect to the course of their nervous processes; viz: (1) ganglion cells with nervous processes which directly become nerve tubes and thus do not lose their individuality

---

[\*Arch. mikr. Anat., 1886.]

though they have no isolated course, *but give off side-branches* to the dotted substance ; (2) ganglion cells with nervous processes which lose their individuality and by subdivisions are *entirely broken up into slender branches*, losing themselves in the dotted substance."

To sum up all, the logical result of Nansen's observations could not long be evaded, and he boldly announces the belief that all ganglion cells are merely nutritive, or may possibly be also seats of memory apparently regarding those functions as closely allied! All really nervous functions proper, on the other hand are referred to the "intricate web or plaiting of nerve-tubes and fibrillæ in the dotted substance." Perhaps this is the result to be expected from two implicit reliance upon the method of metallic impregnation.

Without spending more time in the discussion of these theoretical considerations we may now pass to the study of our sections, and in the present paper confine ourselves to the description of observed structures, reserving their discussion for a subsequent occasion. It, therefore, what follows resembles too closely a bare description of plates, we trust it may serve to prepare for subsequent comparisons.

#### *External form and measurements.*

That portion of the brain in front of the bridge is ob-pyriform, the olfactory lobes corresponding to the stalks of the pear. These lobes protrude 9-10 mm. beyond the hemispheres and are attached to their crura by an oblique plane looking dorsad and caudad as well as laterad. The crura are about 5 mm. wide at the attachment and widen caudad to become continuous with the pyriform lobes and, from hemispherical prominences, sink to slight elevations whose surface is excavated by vessels from the circle of Willis, which cross transversely about 13 mm. from the front. Immediately caudad to this depression the pyriform lobe springs ventrad as a strong protuberance. A well defined white band on the ventro-lateral exposure of the crural expansion indicates the position of one of the external olfactory tracts, which passes parallel to the rhinalis fissure and plunges into the pyriform lobe near the middle of its cephalad portion. A smaller band lies nearer the median line. The greatest ventral projection of the pyriform lobe is opposite the infundibulum and it is the posterior free margin of the lobe which constitutes the hippocampus, to the inversion of which the protuberance is due. The chiasm lies about 10 mm. back of the anterior margin of the hemispheres and there seems to be a small band of the

chiasm system which is partly distinct, lying partly imbedded in the tuber cinereum and crossing directly. Back of the tuber is a well marked trigonum inter-pedunculare, but the third nerves arise from the strongly divergent peduncles near their median margins.

The medulla is coffin-shaped in outline, its sides consisting of a short anterior oblique, a median longitudinal, and a longer posterior oblique portion. The third nerve is relatively large as compared with the opossum, being ten times the size of the fourth nerve, and arises from a number of closely united roots.

The fourth nerve is very small and springs from the very lateral portion of the valve of Vieussen's, thence passing to Gasser's ganglion.

The fifth has two distinct roots, the ventral portion being a broad, flat band extending nearly horizontally from the base of the main root, from which it is elsewhere independent until merged in the ganglion of Gasser.

The main root is ten times as large and is flattened slightly horizontally.

The sixth nerve consists of three nearly equal roots springing obliquely from the posterior margin of the pons and along the lateral margin of the ventral median tract of the medulla, which here is very distinct.

The seventh nerve lies in the same antero-posterior plane as the sixth and 1 mm. caudad to the fifth. It is a rather large, flat band passing directly lateral, its fibres entering the medulla nearly parallel to the surface.

The eighth is partly covered by the seventh when viewed from below, and separates imperfectly at first into its two branches. Its tract passes superficially dorsad under the cerebellum to a prominent eminencia acustica. The ninth and tenth nerves immediately follow but differ in direction. The eleventh can be traced to at least the third cervical. The twelfth arises by three clusters, increasing in size backward and springing from the margin of the medio-ventral tract.

As compared with the opossum, the brain is broad and compact, the olfactory lobes are relatively small, the optic chiasm is larger, the pyriform lobes are more distinct and prominent, the rhinalis fissure more distinct, and the pons is much larger, as are the cranial nerves. As compared with the rabbit the brain is more massive and compact but otherwise exhibits only minor differences.

The following measurements are added :

Total length, 5 cm.; length of olfactory lobes, 12 mm.; front of hemisphere to chiasm, 12 mm.; to posterior third nerve root, 24 mm.; to bridge, 26 mm.; to posterior of pons, 33 mm. Total width of cerebrum at base, 32 mm.; at chiasm, 26 mm.; distance between opposite sulci rhinales at chiasm, 21 mm.; space between opposite pyriform lobes at nearest point, 8 mm.; distance between fifth nerve roots, 10 mm.; distance between seventh nerve roots, 11 mm.; distance between sixth nerve roots, 5 mm.; distance between eighth nerve roots,  $12\frac{1}{2}$  mm.; width of cerebellum at widest part, 25 mm.; width of cord at base of medulla, 8 mm.; width of medulla near lower end, 13 mm.; from anterior of bridge to first spinal nerve, 21 mm.; from anterior of bridge to second spinal nerve, 25 mm.; from anterior of bridge to third spinal nerve, 30 mm.; median length of hemispheres, 47 mm.; width of cerebellum exclusive of vermiiform, 22 mm.

*Structure of the cord and medulla.*

The cross sections of the cervical region of the cord of *Arctomys* show the relations of the white and gray matter to be rather primitive. The minor subdivision of some of the longitudinal columns can not be determined so readily as in higher types.

The central gray matter divides the cord into the ventral, lateral, and dorsal columns. *Fig. 1*, Plate XIII, taken at the entrance of the second cervical dorsal roots, shows the relations of these parts. The ventral column is rather smaller in comparison to the lateral and dorsal columns. It receives fibres from the ventral cornu, *a*, and from the anterior commissure, *b*. The lateral column is uniform in texture and is not susceptible to a division into pyramidal and direct cerebral tracts by any markings on the sections. It receives a constant supply of fibres from the whole extent of the ventral column. The dorsal columns show a decided difference in texture in different parts and can be easily divided into the dorsal or Burdach's columns, *g*, dorsal median, or Goll's columns, *h*.

In Goll's columns the transverse section shows but a small amount of neuroglia and the section is entirely made up of nerve fibres, as will be seen from Plate XIII, *Fig. 7*, while *Fig. 6* of the same plate shows the structure of Burdach's columns and the lateral and ventral



columns to be quite different in having much larger fibres with a considerable amount of surrounding neuroglia.

The ventral root-zone is represented in Plate XIII, *Fig. 2*, and is found to spread out over the greater part of the lateral aspect of the cord. The ventral root does not leave the cord as a distinct bundle, as is the case with the dorsal root, but is formed from an extension of the fibres from the whole side of the ventral cornu, which radiate to the surface of the cord and then converge to the ventral root.

The dorsal root enters as a large bundle. Part of its fibres pass into the dorsal root-zone or Burdach's columns and part pass directly into the dorsal cornu and there enter the cells of the gray matter, while part pass directly to the opposite side through the posterior commissure.

The distribution of the gray matter is essentially the same as that of the rabbit. The ventral cornu is rather broad but very short and contains two groups of multipolar cells. One median group (Plate XIII, *Fig. 1, a*, *Fig. 3*, *Fig. 4, b*, and *Fig. 8*.) is situated at the median angle of the cornu, having cells from .015 to .02 mm. in transverse diameter. These cells send off processes to the ventral columns, which eventually pass into the ventral roots, also processes which seem to pass to the dorsal cornu, and some which pass through the ventral commissure to the opposite side.

The other cell group (Plate XIII, *Fig. 4 c*, *Fig. 9*.) is situated external to the first and forms a lateral nucleus. The cells resemble those of the median group very closely and send their processes in the same directions.

The cells of the gray matter of the dorsal cornu are much smaller than those of the ventral. They occur in greatest numbers in the cervix of the cornu (Plate XIII, *Fig. 1, b*, *Fig. 2*, *Fig. 4, a*, *Fig. 5*.) These cells are from .005 to .01 mm. in transverse diameter and are multipolar in form. The processes to which they give origin follow the direction of the fibres in which the cells are imbedded, but whether they are simply the nodal points of these fibres and do not represent true cells may be questioned. They are nucleated and, except in size, resemble very closely the motor cells of the anterior cornu. Besides these distinct cell groups there are also numerous cells scattered rather irregularly throughout the gray mass, and at the exits of the ventral roots. These cells, which lie lateral to the central canal, increase greatly in number and size and appear to form a large nucleus

occupying the whole ventral cornu and middle gray portion. (Plate XIII, *Fig. 4, d.*)

Passing cephalad into the medulla, in a cross section taken just caudad to the decussation of the motor tracts (Plate XIV, *Fig. 1,*) the general arrangement of the gray and white matter is quite similar to that of the cord in the cervical region. The columns of Goll are very much reduced in size, being compressed, as it were, by the decussation of the motor fibres and, a little further cephalad, form the *funiculus gracilis*.

The dorsal caput cornu is much enlarged and the gray matter extends laterally almost to the surface. The gray matter is everywhere filled with cells of the multipolar type, which are scattered almost uniformly through the substantia gelatinosa and the dorsal cornu especially is charged with nutritive corpuscles. This uniform distribution of cells through the gray matter seems to accompany the reduction in the number included in the various nuclei. The nucleus of the ventral cornu (Plate XIV, *Fig. 1, b,*) is still quite manifest, but the second group, which lies somewhat lateral to the first, has lost its identity in the general distribution of cells.

The number of cells present in the median nucleus (Plate XIV, *Fig. 1, d,*) seems to be also somewhat reduced. The cells which were so conspicuous in the neck of the dorsal cornu, (Plate XIII, *Fig. 4, a,*) are also much scattered, while a remnant of them seems to persist though crowded more dorsally, (Plate XIV, *Fig. 1, c.*) We notice also the accumulation of a few cells, somewhat external and lateral to the nucleus of the ventral cornu which is the beginning of a large ventrolateral nucleus extending cephalad, (Plate XIV, *Fig. 1, e, Fig. 5, c.*)

The expansion of the gray matter seems to be due to the insertion of a large number of nerve bundles which are distributed through the gray matter and run longitudinally in the medulla, beginning the formation reticularis of the medulla a little further cephalad. In the section under consideration there is also shown the exit of a small bundle given off to the eleventh nerve root, (Plate XIV, *Fig. 1, a.*) The fibres seem to be derived from the generally distributed cells.

Passing a little more cephalad in a section taken at about the first fourth of the decussation, (Plate XIV, *Fig. 5,*) we find that the nucleus of the ventral cornu has entirely disappeared, while the ventrolateral nucleus (*Fig. 5, c,*) is much enlarged and is composed of cells of the multipolar type, measuring from .03 to .05 mm. in diameter (Plate



XIV, Fig. 3.) The median nucleus (Fig. 5, *b*,) still continues, and there is a gradual separation of the cells of the nucleus into a dorsal and ventral group, as will be seen by reference to Fig. 6, *d*, and *e*, of the same plate. The remaining portions of the gray matter are about as in the previous section. At about the middle of the decussation we find that the median nucleus has entirely differentiated into two distinct nuclei, the ventral being the caudad extension of the nucleus of the twelfth nerve, (Plate XIV, Fig. 4,) and the dorsal, the nucleus of the eleventh nerve. The pyramidal tracts in decussating and passing dorsad are divided up into a great many fasciculi, and these are thickly interwoven with each other in crossing and also with the fibres of the gray matter.

The surface of the fasciculi is very thickly covered with nutritive corpuscles, even more so than the gray matter at this point. The gray matter contains many longitudinal bundles which are seen here in cross section and which mark the first appearance of the *formatio reticularis* of the medulla. In this section also there appears for the first time a small ventral cluster of cells, (Plate XIV, Fig. 6, *a*,) which marks the beginning of the *olivary body*. These cells are rather smaller than those in any nucleus previously discussed, measuring about .02 mm. in diameter. They tend to be bipolar and flask shaped in form and the processes start more abruptly from the cell body. Plate XIV, Fig. 2, represents this entire nucleus.

It may be noted here that our study has led us to the opinion that most of the so-called flask-shaped and unipolar cells are in reality cells of the bipolar type which have been sectioned obliquely to their axis. This will account for the fact that many of the flask-shaped cells are non-nucleated. We do not mean to imply that there are no unipolar cells, for those do in some cases undoubtedly exist, but that in a nucleus the cells all tend to be of the same type and it is with doubt that we accredit the presence of unipolar cells in a multipolar nucleus.

Passing cephalad from this level, the medulla, enlarges rapidly, the *canalis centralis* is flexed dorsad and rapidly expands into the fourth ventricle. There is an aggregation of gray matter towards the median portions and on the floor of the ventricle. The white matter is limited to a narrow zone around the lateral and ventral surface and the reticular formation.

In a section taken at the level of the twelfth nerve, (Plate XV,



*Fig. 1,*) the fibres of the twelfth enter on the ventral surface just lateral to the pyramids, *k*, pass through the olivary body, which attains its maximum development at this point, and then through the formatio reticularis to its nucleus, *b*, on the floor of the fourth ventricle. The cells of this nucleus are of the multipolar type, measuring from .05 to .06 mm. in length, having nuclei about .01 mm. in diameter, with nucleoli. The axis cylinder process generally passes into a bundle of fibres leading to the root of the nerve. *Fig. 5*, Plate XV, presents a magnified view of the entire nucleus as it appears at this point. Just laterad to this is situated the nucleus of the tenth nerve Plate XV, *Fig. 1, a*, and a magnified portion of the same *Fig. 2*, of the same plate. The cells of this nucleus are somewhat smaller than those of the twelfth, though of about the same number and form. Just laterad to this nucleus is a large cluster of small cells which is evidently very closely associated with it.

Still laterad we find a large group of cells which may be divided into two nuclei. The lateral one, (Plate XV, *Fig. 1, c*), constituting the *cuneate* nucleus, contains cells measuring about .03 mm., imbedded in a very dense neuroglia (Plate XV, *Fig. 6*), while the cells of the median portion are very much smaller and are more numerous, constituting the *clavate* nucleus.

The formatio reticularis is very largely developed and rather abundantly provided with cells which are of the multipolar type, measuring about .04 mm. and sending their processes in the general directions of the fibres in which they are imbedded. Plate XIV, *Fig. 4*, will serve to illustrate their manner of distribution between the longitudinal fasciculi of the reticular formation.

There is a marked decussation of fibres in the lower portion of the raphe in which are found multipolar cells of about .02-.03 mm., which here form a considerable nucleus, (Plate XV, *Fig. 1, e*, and a magnified view of the same, *Fig. 3*, of the same plate.) The decussation is of fibres from the olives, while large bundles appear to pass through the olives and thus around into the *restiform* tracts. A small lateral nucleus is also present.

As we pass cephalad, in a section at the level of the entrance of the tenth nerve root, (Plate XVI, *Fig. 1*), we find the nucleus of the twelfth nerve, *c*, still represented on the floor of the ventricle and the nucleus of the tenth, *b*, very closely associated with it. The olives are much reduced in size, the nucleus of the raphe in the decussation

not so largely charged with cells, the cuneate and clavate nuclei have disappeared, the lateral nucleus is still present, while the cells of the formatio reticularis are much more abundant and indicate the beginning of a large median nucleus which is quite conspicuous in the next section, (Plate XVI, Fig. 2, *c*.) This section is taken still farther cephalad and is chosen at the entrance of a few fibres of the ninth nerve root, (Fig. 2, Plate IX.) Most of the fibres of this nerve turn soon after entering the medulla and pass into the longitudinal fasciculi; some, however, seem to lead directly into a small nucleus, *a*, which we term a nucleus of the ninth nerve. At this level we find the cells of the lateral nucleus increasing in number and size and forming quite a large aggregate which can easily be traced as the caudad extension of the seventh nerve nucleus. We have in this section also the first few fibres of the eighth nerve passing in above the restiform body to a large mass of gray matter densely packed with small cells, which we shall term the internal nucleus of the eighth nerve.

The next section is taken at about the level of the middle of the entrance of the eighth nerve and at the union of the cerebellum with the medulla by the *pedunculus cerebelli*, (Plate XVI, Fig. 3.) The eighth nerve enters as a large bundle, *i*, and just within the border of the medulla is located the nucleus of the root of the eighth nerve, *c*, composed mostly of rather small cells.

Following the fibres as they pass into the medulla we find that some of them pass dorsad to the restiform body, *f*, and enter Deiter's nucleus, *b*, in the peduncle of the cerebellum and some turn directly into the cerebellum. Of those fibres which pass ventrad to the restiform body, part turn dorsad and enter Deiter's nucleus from below and perhaps pass through the nucleus into the cerebellum.

The remaining fibres pass through a reticular formation and enter the internal eighth nucleus which is on the floor of the fourth ventricle at *d*, Fig. 3, Plate XVI. The cells of Deiter's nucleus are of the ordinary multipolar type, measuring about .05 mm. in length. The entrance of the eighth root is also shown on Plate XVI, Fig. 6, as is seen in a longitudinal section taken parallel to the base of the medulla. As most of the fibres pass dorsad upon entering the medulla the only nucleus of the eighth shown at the level of the entrance is the nucleus of the root, *b*, of the figure.

Besides the nucleus of the raphe and adjacent formatio reticularis, *e*, of the section, (Plate XVI, Fig. 1,) the only other group of cells

which we will consider, is the large nucleus of the seventh nerve seen at *a*. This nucleus occupies a ventro-lateral position and is quite large with fibres passing from the cells collected into definite fasciculi, which pass dorso-cephalad almost to the floor of the ventricle where they are united into two or three large bundles and turn upon themselves, forming the knee of the seventh nerve, seen in cross section, (Plate XVII, Fig. 1, *f*, and Fig 2, *b*.) The cells of this nucleus are of the multipolar type, with numerous processes and large nuclei. They measure about .07 mm. in length with nucleus .01 mm. in diameter. A magnified view of a small portion of the nucleus is shown by Fig. 4, Plate XVI. Fig. 6, of same plate shows at *c*, the position of the large fascicle of the seventh seen in cross section.

Before leaving the eighth root, it is well to examine one more section taken farther towards the cephalad margin of the root. Plate XVIII, Fig. 1, at *a*, represents the entrance of the fibres, with the root nucleus at *b*. In this section the restiform body has passed into the cerebellum to the *vermiform process* (Ranney), and the fibres of the eighth are not here divided, but pass directly into Deiter's nucleus and upwards into the cerebellum, while the internal nucleus is reduced to a very small cluster of small cells. That fibres of the eighth pass into the cerebellum is without question. We observe also at this level the nucleus of the sixth at *d*, and the forward extension of the olivary body at *e*. The formatio reticularis comprises the largest part of the section.

Examining a section at the level of the entrance of the seventh, (Plate XVII, Fig. 2,) we are able to trace the large bundle of the seventh, *a*, through the formatio reticularis above and medianly to the nucleus of the sixth, *d*, to its flexure or genu. In the same manner the path of the fibres of the sixth nerve are easily traced to their nucleus, *d*, on the floor of the ventricle. The cells of this nucleus are about .05 mm. in length and have their axes in the direction of the entrance of the fibres into the nucleus. (Plate XVII, Fig. 5.) The olivary body, *e*, is also present in this section as a nucleus on the ventral side of the medulla, its cells measure about .02 mm. and have numerous processes which start abruptly from the celi, thus giving them an even outline in appearance under a low power. There is a very evident decussation with its fellow of the opposite side. Fig. 2, Plate XVIII, gives a magnified view of these cells.

The next section considered is taken at the level of the caudad margin of the fifth root, (Plate XVIII, Fig. 3.) The scale upon which

this figure is drawn is a little smaller than the previous figures of the medulla in order to represent the full section and show the relation of the cerebellum to the medulla at this point.

The entrance of the fifth nerve, *a*, is shown in quite a number of sections of the series as the diameter of the root is so great, but we here consider only two of this number. The one under present consideration shows the fibres of the fifth nerve passing to a large motor nucleus, *b*, and to a sensory nucleus, *c*, also fibres passing to the gray mass on the floor of the ventricle. The motor nucleus is charged with very large multipolar cells with numerous processes and large nuclei. For form and size, compare scale on Plate XVIII, Fig. 4.

Passing to the next section (Plate XVIII, Fig. 1,) taken at the middle of the fifth root, we find about the same distribution of fibres and nuclei. In no case are fibres of the fifth nerve traceable to the cerebellum directly. The beginning of the large nucleus of the pons, *d*, also appears in this section.

Fig. 6, Plate XVIII, presents a longitudinal vertical section of the medulla and cerebellum, showing the entrance of the fifth nerve, *a*, and the eighth nerve, *e*, with its root nucleus, *d*. In the longitudinal basal section of the medulla at the level of the eighth nerve (Plate XVI, Fig. 6,) the entrance of the fifth nerve, *a*, is also seen with a large bundle of fibres extending caudad and some turning to a nucleus (probably motor) at *d*.

At the entrance of the fourth nerve, in the section taken on a level with the valve of Vieussens, the fibres of the fourth enter and decussate with those of the opposite side, and then pass ventrad and cephalad to their nucleus. The nucleus of the pons, *a*, is very large and almost entirely surrounds the pyramidal tract, *g*. The cells of this nucleus measure about .02-.03 mm. and are imbedded in a dense neuroglia, their processes are short and the cells under a low power have a quite regular outline and bear a striking resemblance to the cells clustered in the central gray mass bordering the aqueduct of Sylvius, as will be seen by comparing Figs. 4 and 5, of Plate XVIII, taken from the two regions. There appears to be another aggregate of cells in the central gray mass at *c*, the cells of which are quite small, flask-shaped, and bipolar, mostly measuring about .01 mm. The raphe and the formatio reticularis are here highly charged with cells and present the appearance of one large nucleus.

Horizontal sections, including the anterior portion of the medulla

and the entire higher portions, afford opportunity to trace the connections of the structures already described with the cerebral ganglia.

*Nuclei and tracts of the higher portion of the medulla and cranial region, as seen in horizontal sections.*

*The bladder cells of the dorsal root of the trigeminus.* These remarkable cells have already been referred to. They seem to have been first recognized by Stilling, who regarded them as forming an accessory nucleus of the fourth nerve, in whose tract they nearly lie. Stieda (*Zeitschrift f. wiss. Zoologie*, Band XX,) falls into a worse error, regarding these cells as the true nucleus of the fourth, and failing to discover the tract extending from the root cephalad, (*Loc. cit.* Plate XX, Fig 44.) Stieda's drawing is exceedingly conventional, so far as concerns cells and nuclei.

Meynert (*Striker's Histology*, Am. Ed., p. 705,) describes the cells in question as follows:

"The cells from which spring the above mentioned roots of the fifth pair, differ strikingly, in regard to their shape, from the cells in the common nucleus of the oculo-motor and trochlearis. The former are inflated, bladder like, and furnished with but few and slender processes, which project abruptly from the cells like a straw from a soap bubble. The latter are large, like the former, but slender, and rich in processes whose calibre passes by gradual transition into that of the cells. The former resemble the cells of the spinal ganglia, the latter those of the anterior cornua of the spinal cord."

"Even within the limits of the upper corpora bigemina, the central tubular gray matter encloses the nuclei which give rise to the motor nerve roots referred to (oculo motor, etc.), which lie more or less near the median line; also a laterally disposed sensory nerve tract, the roots of the fifth cranial nerve. The fibres composing these roots originate at the outermost border of the gray matter which surrounds the aqueduct of Sylvius in small collections of large bladder-shaped cells 60 micr. in length and 45-50 micr. in breadth."

In *Arctomys* the disparity in size between the cells of the nuclei of the fourth nerve and these bladder cells forbids comparison, otherwise the remarks quoted apply substantially. The deduction which Meynert attempts to draw regarding the relative position of sensory and motor nuclei in the medulla seems forced in this case, being based on the pure assumption that these cells are sensory, while the differ-



ences between any known sensory cells and those in question are certainly as striking as their resemblance.

Similar cells have been described by Belonci, in birds, Stieda in the turtle, and Herrick, in the alligator. As a matter of fact, no substantial basis exists for determining the function of these cells. Their similarity to Purkinje's cells of the cerebellum gives some force to the suggestion that there may be similarity in function if not in origin, though the resemblance is still greater to the cells of the ganglion of Gasser.

These bladder cells are especially well seen in the horizontal sections passing through the nuclei of the third and fourth cranial nerves. (Plate XIX, Fig. 2, *Bc. Bc'*, Fig. 4, *b.*)

These cells are .05-.07 mm. in diameter and of a baloon or flask shape or polyhedral. The processes are few, and abrupt, and give rise to a very large fibre. Such cells are first encountered in the base of the tectum opticum, near the highest part of the nates and are sparsely scattered in the tract which passes in a gentle curve laterad and caudad and at the same time, somewhat ventrad, to form a disperse tract about the aqueduct and thence caudad to the anterior part of the fourth ventricle. Here the cells are most numerous and lie peripheral to the strong motor nucleus of the fifth, which lies near the ventricle. Although the two sorts of cells commingle in places, there is never any difficulty in distinguishing them. The general relation is always that described. The tract can be traced laterad and ventrad and the nucleus itself describes a strong lateral curve at the point of departure of the root tract, while scattered cells of this type can be traced to the point where the fibres are lost in the common root of the fifth.

*Motor nuclei of the trigeminus.* The cephalad portion of the trigeminal motor system is quite complicated. The highest recognizable portion is the elongate cluster bordering the caudad portion of the aqueduct and the cephalad part of the fourth ventricle. The cells are figured, (Plate XIX, Fig. 4, *a.*) and are of the usual motor type, measuring .05-.06 mm. in length, by .02-.025 mm. in width. The prevailing direction of the principal processes is caudad, *i. e.* toward the root, the opposite extremity being multipolar.

A second nucleus lies ventro-laterad from this one and appears in horizontal sections through the highest portion of the root of the fifth. It lies nearly opposite the caudad part of the pre pedunculus cerebelli and is of circular outline and about fifty cells lie in one horizontal

plane of its middle portion. The cells are fine examples of the multipolar type.

This nucleus does not extend dorsad to the level of the sixth nucleus, which is a relatively broad zone with little dorso-ventral extent. The cells of the sixth nucleus lie with their axis from the median toward the lateral line and their fibres evidently decussate.

The same horizontal section (VII 6-19) displaying the nucleus of the sixth shows the knee of the seventh, lying between it and the median line and enveloping it anteriorly and posteriorly, as already described.

Scattered cells, apparently of the trigeminal system, lie dorsad to the structures just described.

Ventrally, the ventral nucleus of the fifth divides into two ill defined clusters, the medio-caudad portion being approximated to the root tract of the seventh, which latter subdivides into a larger cephalad and smaller caudad portion.

*Nucleus of the pons.* The whole ventral part of the pons is filled with cells, which here and there collect into considerable and distinct nuclei. The cells are relatively short and paraxial with numerous processes, the largest of which pass transversely, *i. e.* in the direction of the pons fibres. These cells are comparatively small, but their nuclei preserve a good size, thus: cells .030-.035 in. diameter, nuclei .008 mm. The fibres can be traced from cells of the caudad portion of the nucleus laterad and caudad for considerable distances to the root of the fifth. (Plate XIX, Fig 3.)

The sections at the level of the motor nucleus of the seventh show that a part of the anterior portion of the pons nucleus is cut off by the passage of the latero-ventral strands of the pyramids and lie between those bundles and the pre-peduncular tract from the cerebellum. Fibres from the cluster in question pass to unite with a nucleus of similar cells at the immediate roots of the fifth.

*The seventh nucleus,* as seen in horizontal sections at the level of the emergence of its root is divided into three portions lying parallel to the median line. The cells are beautiful illustrations of the multipolar variety (Plate XIX, Fig. 5,) and afford ample suggestion, if not proof that the fibrillar terminations of the processes described by authors are due to the disposition of connective tissue web in which they hang.

*The Cerebellum.* Before adverting to the few observations we



have made upon the cerebellum it may be proper to enumerate some of the results of the late investigations of Golgi (*Sulla fina anatomia degli organi centrali del sistema nervoso*, 1886,) of Ramon y Cajal (*Revista trimestrial de Histologia normal y patologica*, Aug., 1888,) and, more recently, of Prof. Koelliker, which seem not to have attracted the attention they deserve in America.

It remains to be seen how far the metallic impregnation upon which Golgi's method rests, develops normal structures and how far it may be relied on to differentiate solely nervous tissues. Really successful hæmatoxylin and cochineal stains will reveal most of the details, though less conspicuously, and are not open to the objection that the stain may be a more or less mechanical precipitate rather than a truly selective stain.

Golgi's chief discoveries are the following: The Purkinje's cells have two sorts of processes, the peripheral protoplasmic processes, which subdivide almost indefinitely, but do not terminate in nerve fibres or a nervous reticulum, and a median axis-cylinder process, which is occasionally furnished with lateral branches.

In spite of the numerous subdivisions of the process, anastomosis is said never to take place between different cells. The Purkinje's cells lie between the outer or molecular zone and the deeper or granular zone.

In the former layer Golgi recognized small cells of variable form with both branching and axis-cylinder processes, which latter also subdivide but do not reveal their ultimate course.

In the granular layer Golgi found small nerve cells with a delicate axis-cylinder process and short and few protoplasmic processes extending to granular aggregates. There are also, still more rarely, larger cells of a fusiform shape and very numerous branches of the axis-cylinder.

Golgi claims that the medullated nerve fibers in the white layer, and especially in the granular and molecular layers, anastomose largely. This latter fact is not substantiated by Cajal, who, moreover, considers the axis-cylinder of the granular cells, and of the small cells of the molecular layer as well as those of the larger cells of the granular layer as non-medullated.

Koelliker summarizes his own observations in the following aphorisms:

"All free, non-medullated processes of nerve-fibres are, in

opinion, undoubtedly to be regarded as centrifugal. All medullated fibres springing from cells are centrifugal. Branching protoplasmic processes of cells are perhaps centripetal, while the so called nervous processes of these, even where non-medullated, may be centrifugal."

(1.) The granular layer contains, besides scattered ganglion-cells, innumerable multipolar nerve cells, both larger and smaller.

(2.) The very numerous small granular cells have only short protoplasmic processes terminating at the end in a brush. The very delicate nervous process usually springs from one of the protoplasmic processes and passes vertically into the molecular layer, where it divides into two unbranched fine fibres running horizontally and longitudinally.

(3.) The large granular cells are less numerous and their densely branched fibres may penetrate deep into the white zone. The nervous process is abundantly branched in a small area and seems not to pass beyond the granular layer.

(4.) Purkinje's cells do not anastomose. The nervous process has a few fine branches ascending to the molecular layer.

(5.) The small cells of the molecular layer are separable into outer smaller cells and the inner or basket cells. The former are provided with strongly branched protoplasmic processes and a nervous process, the course of which is not yet known.

The basket cells have long, strongly branched protoplasmic processes, which may extend to the outer edge of the molecular layer. The nerve process is very long and passes transversely over the bodies of the Purkinje's cells and here and there sends downward perpendicular processes which subdivide and envelop the body of the Purkinje's cells in a basket-like reticulum.

(6.) The medullated fibres in the adult cerebellum do not divide, except rarely in the molecular layer.

(7.) The results of Golgi's method reveal no actual anastomosis of cells and does not suggest any ground for assuming the existence of a nervous reticulum.

Our own work has been too superficial to justify extended criticism of the results quoted, but we venture a few suggestions

1st. Successful hæmatoxylin staining brings out the nervous elements with certainty and reasonable clearness. Golgi's method is liable to introduce error, in that the staining involves connective tissue elements and is variable.

2d. Our preparations show with perfect clearness in Purkinje's cells a basal process and one or more strong peripheral processes, which latter seem to us to be continuous with a system of transverse fibres lying in the molecular layer. The molecular layer contains sparsely scattered Deiter's ("glia") cells which stain deeply with hæmatoxylin and cells of the connective tissue system, which include those mentioned by Koelliker.

3d. The fine branching processes of peripheral and basal processes of Purkinje's cells are probably not nervous.

4th. The "basket cells" of Koelliker are almost certainly of connective tissue character.

5th. Haematoxylin staining brings out quite evidently the large nerve cells of the granular layer, but we suspect that the ramifications described by Koelliker are, in this case also, the result of differentiation of the connective-tissue frame work of the cell.

6th. Branching of the nerve fibres of the white central layer is rare.

We are driven to reject the results of the Golgi method from the resemblance of the structures produced to those constantly encountered and demonstrably the result of the intricate meshwork of connective tissue in the form of hollow sheaths enveloping the cells. Each nerve cell is loosely enveloped in such a sheath, which can be separated by proper treatment, and this sheath is produced in numerous directions into tubular or conical projections which may branch and ramify extensively. The same sheath may expand in a nodular manner to envelop another cell or embrace a fibre and may ultimately terminate in a number of brush like fibrils attached to some membrane or fibrous strand. We believe this explanation is competent to account for many of the complicated structures described by Golgi.

In the great majority of Purkinje's cells, for example, we can trace a single strong process (these are numerous in the opossum), peripheral nearly to the surface, with little diminution of size, and perfect distinctness and with no lateral branches whatever. Hundreds of such cases are before us where a perfectly distinct uniform branch can be followed to near the surface and another of smaller diameter median through the granular layer. The nervous protoplasm in the cell and in both fibres is colored similarly.

Furthermore, no rational interpretation of the structure described by Koelliker seems possible, while the arrangement we observe seems

to coincide with the physiological requirements of the organ. The great simplicity of these cells in *Arctomys* adapts it for their study. We incline to accept Beevor's suggestion in part, *i. e.*, that the ascending processes of Purkinje's cells turn at right angles and connect with fibres leading to the brain

*The Mesencephalon.*

We preface our own observations with Stieda's account of the corpora quadrigemina in the rabbit, which is as follows:

"The peduncular region has the following nuclei. Above the united pyramid tracts and lower longitudinal bundles is a cell group on either side, each of which consists of two parts. The under (ventral) portion is the larger and contains many small cells (.012-.16 mm) in a granular ground mass; the upper, smaller portion has large angular cells of .14 mm. diameter. This nucleus may be called *Nucleus peduncularis*. On the lower margin of the central gray, thus near the floor of the aqueduct, is the oculomotor nucleus of either side. It consists of cells of moderate size (.04 mm.) and angular form. Between the two nuclei and near the floor of the ventricle are numbers of small triangular or fusiform cells. The fibres from the oculomotor nucleus are very numerous and pass through the nucleus peduncularis and between the bundles of the anterior columns to their roots."

"The central gray of the posterior corpora quadrigemina is limited by fibre tracts. Laterally the nucleus of the trochlearis is mingled with these fibres. [The author's figures are here derived from the dog, and we are left in doubt as to the condition in the rabbit, though he explicitly states in a foot-note elsewhere that he introduces references to drawings of other brains that are described only where they are similar.] The nerve-fibres of the corpora quadrigemina are partly transverse, which decussate in small bundles above the aqueduct, and partly oblique bundles."

"The central part of the nates is, like the other gray matter, composed of small nerve cells scattered in a granulate mass, but the superficial portion exhibits distinct interstratification of a white zone parallel to the surface. With high powers an outer zone devoid of cells, may be seen; below this a zone of granulated substance with scattered small cells, then a layer of numerous transversely cut bundles of fibres separated by gray substance, containing stellate nerve cells (.008-.012 mm.) with well-developed processes."

"Then follows a layer of gray matter, with associated fibres. Between the prominences is a considerable commissure of fibres which lose themselves among the longitudinal fibres."

"The fibres on the surface of the corpora quadrigemina I unhesitatingly regard as the real roots of the optic nerve."

(In this latter statement Steida is doubtless mistaken.)

The sections figured on Plate VIII, Figs. 1, 2, and 3, and Plate IX, Figs. 1-5, will convey an idea of the changes observed in successive sections.

Fig. 1, Plate VIII, indicates the structure of sections at the posterior commissure. The nates above are cut near the anterior (cephalad) border. They are at this point receiving fibres from the latero-dorsal optic tract. Some fibres associated with the latter, however, dip downward and medianly to interdigitating masses of gray matter in the lateral aspects of the posterior commissure, Fig. 2, *c*. (See Fig. 7.) Above the commissure is a protuberance of gray matter, looking toward the inter-natal cleft, which resembles the nates and seems to have no special significance. Below the commissure are masses of gray matter, composed of small cells of various forms, though chiefly pyramidal, with long processes, which in position as nearly resemble the colliculi as any structures of lower vertebrates. The bundles entering the posterior commissure diverge rapidly and arch over the last mentioned body, soon passing caudad out of the section. The posterior commissure seems not to be a true commissure but, in part at least, a decussation.

In the median line below the aqueduct there is a collection of cells (Fig. 9,) of the fusiform variety, occupying the position of the raphe. Beneath the optic tract is a large mass of gray substance (corpus geniculatum externum) perforated at intervals by well-defined tracts, which externally lead obliquely toward the periphery and medianly dorsad. The cells are scattered and small, but very acutely angular and of a multipolar variety. A similar body (corpus geniculatum internum) lies below it and only separated by a tract of irregular fibres. Its fibres pass cephalad and medianly. Still another small but rather definite nucleus lies in the latero-ventral region within the longitudinal ventral bundle, which here is peripheral. The entire central portion (*formatio reticularis*), is a reticulum of cells and fibres surrounding longitudinal disperse fascicles. A few very large multipolar cells are scattered in the meshes with the peculiar radiating co-

nective tissue fibrils due to the structure just described. A bundle passing from above nearly parallel to the median line and obliquely caudad, seems to be Meynert's bundle, as seen in longitudinal sections.

Sections caudad (Fig. 4,) indicate the rudiment of the ventricle of the optic lobes so prominent in reptilia, etc. The fibre tract above this may be distinguished as the commissure of the optic lobes or simply optic commissure.

*Sections posterior to the nates* and therefore passing through the testes near their base and nearly parallel to the base are, because of their position, at right angles to the nates.

(Section immediately following Fig. 5, Plate IX, VI-c-25.) The outline of the section is approximately semi-circular, the upper surface being truncate. The aqueduct which lies near the dorsal aspect is rhombic with the angles produced in the horizontal and vertical planes. The bridge is abruptly separated from the peduncular portion, except ventrally, where its fibres separate into fascicles inter-digitating with each other and leaving intervals which are filled with densely nucleated gray matter. The dorsal half of the section is composed of nearly homogeneous, finely nucleated gray matter, in which are no well-limited nuclei-portion of testes. The latero-dorsal angles are occupied with obscure and ill-defined longitudinal tracts. The lateral aspects of the dorsal half are occupied by arching fibre tracts passing ventrad which seem with little doubt to be backward continuation of fibres descending from the nates. The tract disappears by passing caudad out of the section at a point dorsad to a well-defined nucleus lying just laterad to the ventral pyramids, which latter here form strong bundles with oval sections. The nucleus just mentioned (pons nucleus,) is similar to the gray matter filling the interspaces between the pons fascicles.

Upon the dorsal aspect of the ventral pyramids is another small nucleus, having a narrow encircling band of gray, with the longer axes of the cells parallel to the plane of section and at right angles to the fibres.

Above this nucleus is a small circular cluster on either side near the median line, consisting of larger multipolar cells. Still dorsad and in the ventral aspect of the dorsal longitudinal fascicle, is a larger nucleus on either side, likewise circular in outline and densely packed with cells of median size and irregular contours. The area immediately surrounding the aqueduct is homogeneous and sparsely sprink-

led with small cells, except along the raphe, where is the usual nucleus, and a short distance on either side, where a disperse nucleus in the position of the fourth still remains. In the lateral parts of the area about the aqueduct are a few of the large, nearly spherical or polygonal cells. ("Bladder cells" of descending tract of the fifth.) The tracts of the fourth nerve appear as two or three transversely cut bundles at some distance laterad of the aqueduct. The dorsal longitudinal fasciculus lies about one fifth the way from the aqueduct to the ventral surface and its lateral portions curve ventrad to almost unite with the ventral tract.

Passing cephalad a short distance, the nucleus of the fourth nerve appears immediately dorsad to the dorsal longitudinal fascicle. It consists here of very irregular polygonal, multipolar cells measuring about .027 mm., while the nucleus of the raphe consists of a dense aggregate of fusiform elements immediately ventrad to the aqueduct, which at this point is a transverse slit. The dorso-lateral tract now forms a conspicuous prominence ventrad to the nates fissure. The nates posteriorly exhibit a conspicuous radiating structure of the cortex which appearance is heightened by the very numerous blood vessels which pass toward the centre in a direction parallel to that of the nerve chains. Medianly, sections (VI c-20) display a number of fibre tracts in section, which are doubtless continued from the optic tract and enter obliquely from the antero-median aspect. Proceeding cephalad these bundles increase in number.

A comparison of the nates with the optic lobes of lower animals reveals what at first seems a fundamental difference. While in reptiles and birds the fibres of the optic tracts pass directly to the periphery of the tectum opticum, in mammals these fibres appear to pass into the deeper portions. In reptiles pretty definite chains can be traced from periphery to base of the tectum with insulating, columnar connective tissue apparatus which forcibly suggests the arrangement in the retina. Nothing of this sort distinctly appears in the mammalian nates. The reptilian tectum is characterized by the presence of a few scattered cells of great size which resemble greatly Purkinje's cells of the cerebellum and are especially abundant in the deeper layers of the interval between the two tecti. Such cells have not been carefully described in mammals, hitherto, to our knowledge, though figured by Bellon in birds and by Herrick in the alligator, and discovered in great abundance in the same portion of the brain of the turtle, by Coppock



the opossum, one of us has found these cells widely distributed through the corpora quadrigemina and thalamus about the roof of the third ventricle and aqueduct, as well as the tectum opticum. We have thought these cells indicative of a low or primitive condition, especially as these cells seem in Didelphy to be devoid of processes. There seems to be no doubt that the cells of this sort lying behind the roots of the fourth nerve constitute a nucleus of the fifth, and the connection of these cells with the entirely similar cells of the tectum opticum is clearly suggested by the course of the fibres as already pointed out. What the reason for the dispersion of these cells so irregularly through the higher regions may be cannot be determined, nor yet the definite connections existing between these large cells and the adjacent structures. See Fig. 3, Plate IX, where such cells should be indicated in the outer lateral border of the gray matter surrounding the aqueduct. (See Osborn, Journ. Morph., Vol. II.)

*Horizontal sections through the mesencephalon, etc.*

The lowest (most ventrad) sections passing through the pars peduncularis exhibit the lateral fibre tracts formed by the pyramids, within which lie the cross sections of the 8-10 bundles of the oculomotor. Immediately in front of the pons medianly is a circular prominence occupied by the interpeduncular nucleus and transverse decussating fibres. This body seems to be merely a nodular prominence of the raphe. The body in question lies 4 mm. behind the posterior margin of the tuber cinereum. The few cells occurring in the nucleus are small flask-cells. At a slightly higher level there appear two distinct nuclei, one seeming like the forward continuation of the pons nucleus and lying caudad to the tracts of the third, the other slightly laterad and cephalad to these tracts. The latter consists of multipolar cells of medium size imbedded in a dense reticulum which seems to be merely the cross section of Meynert's bundle.

At the ventral level of the peduncular nucleus the eleven fibre bundles of the third root have nearly reached the median line. The nucleus is disperse and extends cephalad some distance beyond the nerve roots. At this level there is a marked decussation of the longitudinal fibre bundles immediately behind the third roots. The decussating fibres curve laterad and caudad, passing in this section to the nucleus at the base of the peduncles of the cerebellum.

Fig. 2, Plate XIX, sufficiently illustrates the topography of a hor-

horizontal section at the level of the third and fourth nuclei. A dense nucleus, (*N. interpatheticus*), occupying the region of the raphe caudad to the fourth nucleus is conspicuous. In higher sections the emergence of the fourth root tracts by a number of small bundles describing an abrupt outward curve, is well shown. The interpathetic nucleus above described now lies in the median plane between the nuclei. While no decussation was observed, we are convinced that fibres from the third are given off to tracts passing caudad and laterad.

The relations of the tegmentum with the corpora quadrigemina may be best studied in longitudinal vertical sections. (Plate XIX, Fig. 1.) The nates are nearly quadrangular and inclined posteriorly while the testes lie nearly at right angles to the former and do not reach one-half the size. Fibres from the optic tracts spread out upon the surface of both anterior and posterior corpora and are followed with difficulty.

In *Didelphys* the testes are much more prominent than the nates, and contain relatively more gray matter. The tectum proper is not developed below the lateral plane passing through the third nerve nuclei. In this plane there appear to be five lateral nuclei, three in the thalamus and two in the mesencephalon. The median part of the section is filled with cells, constituting one unsegregated nucleus. We have been able to convince ourselves that the fibres from the optic tracts do not spread out upon the surface of the tectum, but rather are over-capped by a cortex similar to the cerebral. Thus the portion above the aqueduct is separable into four gray layers with three white zones bounding them. The innermost gray zone is immediately surrounding the ventricle and is filled with small cells. (Plate IX, Fig. 3, etc.) This zone is limited by the decussating tract of the nates, in which are found the bladder-cells connected with the superior nucleus of the trigeminal.

The second gray zone seems to partake of the structure of the formatio reticularis and contains scattered nuclei and is bounded peripherally by a discontinuous zone of fibres, apparently extending obliquely caudad. In connection with these fibres are numerous large multipolar cells, whose processes can be traced in various directions, especially peripherad, for long distances. The space intervening between this tract and the tract formed by the fibres from the optic tracts is a reticulum of fibres and cells in concentric and radiating chains. A few of the large multipolar cells are likewise sparsely scattered through

it. The remaining zone of gray is the cortex, and is connected by fibre and cell chains with at least the two median layers.

In just what way the cortex is related to the optic tract is difficult to determine. In some places there is still a superficial fibre tract corresponding to the stratum zonale. The outer layer of the nates contains, as already said, radiating systems of fibres and cells. Of the latter four kinds are recognized. First, a system of superficial pyramidal cells, with their bases peripheral, each with a single process passing toward the center. These cells measure .017-.02 mm., with a nucleus .006 mm. in diameter. The protoplasm stains very faintly and the cell gives off a process which may unite with cells of the fourth sort. It must be left at present undetermined whether these cells are really nervous or not. We could not be certain that basal processes connect them with the superficial fibre zone. Second, very numerous nutritive cells of the usual type are scattered irregularly. Third, nucleated cells of the walls of the blood vessels differentiate strongly. Fourth, elongate, bipolar, fusiform cells, .013 mm. long by .003 mm. wide. Below these, and apparently connected with them, are much larger cells of somewhat pyramidal form, with a single peripheral process, blunt proximal extremity with several processes, and a large nucleus. These cells measure .024-.027 mm. in length by .01-.013 mm. in width. Fig. 6, Plate XIX, is a semi-diagrammatic illustration of the cells of the superficial layer, as seen in longitudinal section (VII-e-2) under the one-fifth inch objective.

(Consult in this connection *Tartuferi*, Sull' Anat. Minut. dell' Eminenze Bigem., etc., in *Revista Sperimentale*, 1879, *Ganser*, Die periph. u. cent. Anordnung d. Schnervenpaare u. d. Corpus Bigem. Ant., *Archiv. f. Psychiatrie*, Bd. XIII., *Nonakov*, Die Beziehung d. sogenannt. Sehphaere z. d. infracorticalen Opticuscentren, etc. *ibid*, Bd. XIV, and *Bellonci*, Ueber d. centrale Endigung des Nervus Opticus bei d. Vertebraten. *Zeitsch. f. w. Zool.*, Bd. XI.VII.)

At the medio-ventral aspect of the sections which display the entrance of the third nerve roots, Meynert's bundle has assumed the longitudinal direction, forming a transversely-cut tract between the roots of which there are over one dozen bundles on either side. In sections farther caudad than Fig. 1, Plate IX, the ventricle of the optic lobes vanishes without divaricating. The non-appearance of the colliculi, as seen in lower vertebrates, is to be explained as due to this fact, *i. e.*, the substance of the colliculi fused with the sub-natal gray

matter. At this level, too, the tracts from Meynert's bundle apparently enter a small, dense interpeduncular nucleus between the third nerve roots and somewhat caudad to them. A large nucleus, (Steida's *nucleus peduncularis*), laterad to the third root tracts, and another near the median line, *nucleus interpeduncularis*, to which the fibres of Meynert's bundle can be directly traced, are also visible (Fig. 3, Plate IX.) Compare Plate X, Fig. 1.

Longitudinal vertical sections through the corpora quadrigemina at the locus of the third root, are especially instructive as to the relations existing between the third, fourth and other nuclei. (Plate X, Fig. 1.) The figure sufficiently illustrates the chief peculiarities. The nucleus of the third lies chiefly below and laterad from the strong median ascending tract and is largely involved in its fibres. The fourth nuclei are composed of entirely similar cells lying in a group caudad and dorsad to the previous nuclei and lying above the ascending tract and near the sides of the floor of the aqueduct. The tracts of IV are seen as two or three circular sections (tr. IV.)

The descending fibres of what is apparently Meynert's bundle can be traced to a point near the entrance of the third nerve. A strong bundle (tr.) from the prominence immediately in front of the outer passes obliquely caudad and mesiad.

The third nerve arises by a number of very small roots which subdivide on entering the substance of the pes into still smaller strands. The course of the fibres can be easily followed dorsally and caudad to a considerable nucleus a little ventrad from the aqueduct. In transverse section the outline of this nucleus is triangular and consists of two indistinctly separated portions, a smaller (dorsal) portion and a larger ventral mass, from the base of which the fibres radiate ventrad to the tracts through a white zone surrounding it. The centre of the nucleus lies dorsal to the anterior edge of the pons.

Ventrally and a little laterad is the larger nucleus, the cells of which are in some respects similar, but average rather larger, (Plate IX, Fig. 3, #2) but from it no fibres can be traced to the tracts of III which latter, in converging toward the nucleus proper at the median line, in part pass through the substance of this cluster. This *peduncular nucleus* is remarkable in that its cells are exceedingly irregular and wrapped about the strands of the longitudinal tract. These many-branched cells lie in angles of decussating fibres, and like similar cells of the ventral cornua of the cord, send off fibres to the several tracts.

Of these tracts especially well marked is a bundle of arching fibres passing from this nucleus dorsally toward the nates but apparently converging over the aqueduct to the posterior commissure. It may be suggested that this nucleus is centre of co-ordination for the oculomuscular apparatus.

*The region of the third ventricle.*

Horizontal sections through the lowest portion of the tuber cinereum reveal the same structure as described in the tuber of the alligator, *i. e.*, a dense layer of epithelium lining the ventricle, the cells of which give rise to long fibres of connective tissue dividing the space about the ventricle into compartments in which the very numerous flask-shaped cells are closely packed. The entire tuber is filled with these cells. At its posterior portion are two more densely nucleated spots laterad to the lowest point of the fornix tract.

In higher sections the above-mentioned nuclei and the cephalad and caudad parts of the fornix tracts become quite distinct. The nuclei above described, which may be called the posterior nuclei of the tuber, give rise to fibre tracts passing dorsad and cephalad laterally from the cephalad tract of the fornix. About the sides of the third ventricle, cephalad is a large, dense nucleus of small cells, the anterior tuber nucleus, and in front of this on either side, not far caudad of the chiasm, is a small tract in cross section. This small bundle can be traced dorsad for some distance, but its ultimate course is unknown.

The structure about the third ventricle remains quite constant but cephalad from the lamina terminalis is a nucleus of spider-like, slender multipolar cells with remarkably long and distinct processes passing in all directions through a coarse reticulum of fibres (VII 'b-15). Both divisions of the fornix tract lose their distinct contours before the level of the anterior commissure is reached, the caudad tract, especially, fuses with the gray matter of the thalamus. The cephalad portion emerges immediately caudad to the commissure. Meynert's bundle at this level is some distance cephalad to the oculomotor tracts.

Three more or less distinct masses of gray matter appear in the lateral aspect, the middle one being the largest and most densely nucleated and being recognized as the corpus geniculatum.

The most remarkable nucleus remaining is the ganglion of the superior commissure or nucleus of the habenulae. This is a compact

dense nucleus of paraxial multipolar cells greatly resembling in size and form the cells of the third and fourth nuclei. This nucleus is situated in the latero-cephalad portion of the thalamus behind the commissure of the hippocampus. It is related to the epiphysis dorsally and a strong ventral bundle (*tænia thalami*) medianly. The whole dorso-cephalad part of the thalamus is thickly sown with cells, especially medianly, while a dense clustre of cells of the same sort is situated near the median line a short distance cephalad of the posterior commissure. The axial direction of the last mentioned cells is vertical and they give rise to the fibres of Meynert's bundle. The nucleus may be termed nucleus of Meynert's fasciculus.

The ascending fascicle of the fornix after meeting the anterior commissure passes dorsad to it, entering the septum and becoming enveloped in cubical gray masses lying between the corpus callosum cephalad and the commissure of the hippocampus caudad. The gray mass contains numerous small nuclei. Gradually this mass (and with it the fornix fibres) fuse with the hippocampal commissure.

The strong tract descending from the habenulæ passes laterally and disappears in the region of the peduncular tracts and can be traced no further.

*Comparative data from Didelphys.*

The following memoranda are derived from a series of sections from the opossum. Two principal bundles emerge from near the ventral surface of the medulla, anteriorly. The median pair bound the trigonum and are laterad to the small oculomotor nerve roots. These ventral pyramids of the peduncles pass obliquely cephalad and laterad to a point caudad to the chiasm, where they turn abruptly dorsad.

The laterad pair of bundles pass obliquely dorsad from the lateral cephalad aspect of the medulla to the caudad aspect of the mesencephalon.

The second or sensory bundle continues in its dorsal course as a semicircular, and finally a circular bundle, to the horizontal plane including the summit of the anterior commissure; there it begins to break up until, at the level of the corpus callosum and hippocampal commissure it becomes a reticular formation beneath the testes. The further course of these fibres is obscure, but it appears that they are continued cephalad through the thalamus and take part in the decussation of the ar



terior commissure. This commissure, which is so large relatively as to take the place of the corpus callosum of higher mammals, gathers fibres from the entire ventral and occipital region and appears to contain not only decussating fibres, but a large number of co-ordinating strands. The connection with the olfactory lobes is evident and direct.

The pyramidal tracts cross the anterior commissure laterally and form almost immediately a number of separate bundles passing directly dorsad. They may be traced chiefly to the antero-dorsal cortex, though smaller bundles pass caudad and a few isolated fibre tracts from this tract seem to reach the ventro-lateral regions.

Numerous small bundles decussate in the ventral part of the crural region.

The course of the fornix seems to be identical with that of the rodents.

A strong tract from the habenulæ follows nearly the same course already described for *Arctomys*, but the ganglion occupies the very summit of the thalamus, while the ganglion of Meynert's fasciculus occupies the median aspects of the upper part of the third ventricle. The superior commissure is a very short distance cephalad and dorsad from the posterior commissure and its fibres can be readily traced to the ganglion habenulæ. A tract passing from the testes to the cerebellum was provisionally recognized.

We have already intimated that the received statements regarding the absence of the corpus callosum are only apparently true. The microscope reveals the presence of a commissure in the proper position to receive this name. It is a small fibre bundle dorsad and cephalad to the commissure of the hippocampus and is a true cortex commissure. It is not larger relatively than the corresponding bundle in the alligator or turtle and therefore does not impeach the validity of the argument against the common origin of marsupials and other mammals. Other details are reserved for an article now under way.

*Details of successive transverse sections through the thalamus and corpora striata.*

(VI a-19.) Section cephalad from the corpus callosum.

At this level the whole dorsal and outer, as well as dorso-median, cortex is similar and the fibres of the white matter converge toward the striatum. Two sets of fibres may be distinguished, the one passing toward the lateral aspects of the corpora striata, the other being



the commissure. The cortex is about 2 mm. deep and the white fibre layer below is one half as thick. The fibres from any given region gradually accumulate in bundles adjacent to the corpus striatum and finally perforate it obliquely. Here they pursue an oblique ventral course and tend to accumulate in still larger bundles. The larger bundles are in the dorsal part of the striatum, the whole substance of which is filled with small fusiform or flask cells of uniform size and irregular direction. The form of the striatum is here irregularly quadrangular. Besides the fibres radiating to the corpus striatum, the white matter beneath the cortex contains an approximately equal number, which obviously are converging to the corpus callosum. These fibres or rather similar fibres from cephalad parts of the hemisphere collect above the ventricle (by it separated from the striatum) to form the callosal tract, which is separated from the median fissure by a thin septum lucidum. The septum is here crowded with fusiform cells and is separated from the cortex proper by the calloso-marginal fissure. Between the septum and the corpus striatum, ventrad from the callosal tract, is a ganglionic mass like the striatum in its cell structure, but free from fibre tracts and separated from the septum by a poorly aggregated tract. This mass is associated with the body of the fornix.

Below the corpus striatum is the central olfactory tract, which consists of two portions, and is very distinct from everything about it.

The entire ventral portion (or pyriform lobe) is peculiar in the absence of any orderly arranged cortical gray. On the other hand, its cells are aggregated in small, dense clusters or sinuous masses and a little distance within the cortex is a greater number of small, disperse fibre tracts which appear to be derived from the superficial olfactory tract, which latter here occupies the latero-ventral aspect.

(VIa, 21.) In sections near the the front of the callosum the ventricle has extended ventrally and severed the non-fibrous median gray or fornix nucleus, making of it an intraventricular aggregate, the medio-ventral part of the septum lucidum remaining distinct from it. In sections further caudad the tracts near the ventral surface have treated dorsad and collected near the olfactory tract. The tract from the ventral part of the septum has descended toward the ventral region and dense clusters of large fusiform cells gather in its medio-ventral portion.

Gradually the intra-ventricular gray matter (fornix body) assumes a quadrate section, the central olfactory tract begins to reach a medi-

position, and the superficial one spreads over the whole pyriform lobe.

The next section (Fig. 8, Plate II,) taken behind the chiasm shows the optic tracts collected on either side of the now distinct thalamus and separated by the infundibulum. The olfactory tract crosses the narrow third ventricle by a sudden curvature via the anterior commissure which seems to be a genuine commissure of the olfactory and adjacent sensory tracts.

An important tract now first appears. It consists of fibres passing obliquely dorsad behind and ventrad to the commissure. Neither upper nor ventral terminus appears in this section, but the fibres can be traced ventro-laterad and caudad to form the descending tracts of the fornix, as already seen in longitudinal sections, and cephalad and dorsad until they unite the so called fornix nuclei of both sides by a strong decussational band near the ventro-caudad border of the callosum. We can not determine whether there is absolute continuity between all these fibres and the commissure of the hippocampus. The latter is certainly chiefly made up of the fibres from the fornix, but it also appears that some of the fibres from the hippocampus are truly commissural while, on the other hand, some at least of the fornix fibres appear to terminate in the gray matter of the fornix nucleus or body.

The farther course of the descending tract of the fornix has been given above. We do not find evidence of the absolute continuity of the fibres of this tract with those of the fasciculus of Vicq d'Azyr or ascending fornix tract of Ferrier.

The body or nucleus of the fornix adheres to the inferior surface of the corpus callosum, but there is no evidence of organic connection.

Plate I, Fig. 8, illustrates a section near the front of the corpus callosum. The fornix body has already become distinct from the corpus striatum. The central tract of the olfactory nerve lies ventrad and slightly dorsad from the line *c*, the external tract being near *b*.

Plate II, Fig. 8, represents a section at the anterior commissure. The prominences of the fornix body are here quadrangular and medianly give rise to tracts which pass caudad to the commissure. The optic tract appears near the median line above *1*. Plate IV, Fig. 1, exhibits the relations of the tracts descending from the fornix nucleus. In sections immediately following, a very broad band of fibres connects these two prominences and their extension also unites the ventral surfaces of the hippocampus. This belt of fibres has suffered the same involution that the substance of the hippocampus has, and in

consequence has been rolled into a band with a semicircular section, so that a section further back (Plate IV, Fig. 2,) reveals the fornix fibres dorsally attached to the hippocampus. This throws needed light upon the fornix, hippocampus, and their relations. The hippocampus is essentially the whole caudad margin of the cortex which by continued peripheral increase has rolled itself in the longitudinal direction and at the same time arched about the peduncles as they converge from the striatum toward the sides of the thalamus. This passage of the peduncular fibres can be well seen in sections somewhat cephalad to Fig. 1, Plate V, and in Plate V, Fig. 2, where the peduncular fibres have already crossed and lie mesiad from the optic tract which forms the lateral wall of the thalamus. Near the lower ventral and median extremity one may detect the remnant of the fornix tract on its way to the mammillary body. Laterally, the ragged portion of gray matter projecting into the ventricle is the remnant of the striatum after the crossing of the fibres to the thalamus.

Returning to the hippocampus, its fibres pursue as nearly as possible the usual course, *i. e.*, part pass directly across, forming the commissural part of the fornix, and other fibres descend in the body of the fornix to the body of the thalamus and thence to appropriate nuclei in that organ.

In the region of the anterior commissure, a number of the ventral bundles of fibres, which may be regarded with a high degree of probability as sensory in function, now begin to cross to the thalamus, meanwhile the dorsal bundles which occupy the striatum proper become constantly more compact. The principal sensory bundles seem to be driven medianly until the sides of the thalamus are occupied by a rather compact motor column. The relations described are well shown in Figs. 1 and 2, of Plate V. Fig. 2 also shows the fornix fibres near the mammillary body.

The olfactory tracts are somewhat difficult to follow. Two of them are distinct and may be traced to the same general region of the hemispheres and thalamus. The inner tract passes directly backward from the centre of the crus olfactorius (Plate II, Fig. 1,) to beyond the anterior cornu of the ventricle, where it seems to divide, sending a branch to the superficial tract. Thence it may be traced backward in successive transverse sections to the region of the anterior commissure. (In Fig. 8, Plate I, the olfactory tract lies a little above and to the left of the point indicated by *c*.)

The superficial tract of the olfactory fibres passes along the ventral surface in ill-defined bundles to the hippocampal region. Here small, dark, angular, multipolar cells abound, similar to those of the anterior or fornix eminentia of the thalamus. The relation of the hippocampus with the fornix has already been indicated. It is probable that fibres from the hippocampus pass to the higher cortical regions via the fornix commissure, just as in the reptilia. It is not impossible that there is a connection of the central tract with the hippocampus, but such a communication was not demonstrated.

Other fibres seem to depart from the main tracts and gather at the anterior commissure. The anterior commissure in the brain of the rat was studied for comparison with the result of confirming the suggestions already made.

The transverse sections have thrown no light on the course of the fibres from the dorsal nucleus of the thalamus (*taena thalami*), which in horizontal sections are found to pass ventrad along the cephalic border of the thalamus, behind the callosum and anterior commissure, to the point of entrance of the pyramidal fibres into the hemisphere. We think it probable that these fibres make their way to the hippocampal or occipital region of the cortex.

#### *The Prosencephalon.*

(It will be convenient in presenting the few notes we at present offer upon the fore-brain, to reverse the order hitherto followed.)

(a.) The *olfactory lobes* are of considerable size and are connected with the cerebral hemispheres by a relatively thick crus olfactorius. The form of the bulb proper is ovoid and it is obliquely appressed upon the front of the hemisphere.

Microscopically the structure is not unlike that of the human subject. The outermost layer consists of bundles of olfactory nerves passing in various directions to unite with the glomerular layer. The exact method of emergence was not observed. The so-called glomerular layer is simply a belt of fibre bundles, each bundle being surrounded by a cluster of "neurilema nuclei." The olfactory fibres are more or less convoluted and are separated by a dense reticulum of neuroglia. The glomerular layer insensibly passes into the more homogeneous but otherwise similar gelatinous layer. Here the olfactory fibres pass through a dense net-work of connective tissue with sparse neuroglia nuclei. Forming the inner boundary of the gelatinous layer

is a layer of ganglion cells. These cells are pyramidal and give off three or more acute projections peripherally, but extend into a thick axillary process below. The number of ganglion cells is relatively very small. The bases of these ganglion cells are immersed in a dense zone of neuroglia nuclei, which are oval and furnished with very prominent nucleoli, one always being central, they are not more than one-fifth the length of the ganglion cells, and their function may be to nourish the ganglion cells and insulating layer of the centripital nervous processes. The following layer is composed of nerve fibres, which are collected in bundles closely invested by nuclei similar to those above described and divided into upper and lower tracts by the olfactory ventricle. The dorsal part of the crus olfactorius has a cortical layer, differing materially from that of adjacent parts of the cerebrum.

The course of the fibres is difficult to trace in detail. There are two distinct tracts, the upper passing directly to a point below ventral point of the lateral ventricle, partly mingling with the cortical fibres of that region and passing through the base of the corpus striatum, but giving off a branch which unites with the lower superficial tract which passes obliquely backward upon the surface to what has been called the pyriform lobe.

Fig. 9, Plate I. Transverse section of olfactory lobe. (a.) granular layer, (b.) gelatinous layer, (c.) position of ventricle, (d.) ganglion layer, (g.) glomerular layer, (f.) fibre tracts.

Fig. 1, Plate II. Longitudinal section of anterior part of hemisphere and olfactory lobe. Fig. 1a, fibre bundle, enlarged. Fig. 3, Plate II, section through ganglion and adjacent layers, much enlarged. Fig. 2, Plate II, portion of cortex at base of crus olfactorius.

[NOTE.]—Although most of the time devoted to this paper has been employed in the study of the histology, especially of the cortex, this section must be omitted till the next issue, because of vexatious delays.



## EXPLANATION OF PLATES.

The sections are all drawn, unless otherwise stated, by means of the camera lucida.

### PLATE I.

C. L. HERRICK.

Transverse sections of the right hemisphere of *Arctomys* to a uniform scale.

*Fig. 1.* Cross-section of olfactory bulb. *Cf.* *Fig. 9.*

*Fig. 2.* Cross-section of hemisphere and crus olfactorius.

*Fig. 3.* Cross-section of hemisphere at the junction of the crus olfactorius.

*Figs. 4-8.* Sections taken at frequent intervals across the hemisphere, extending as far caudad as the corpus callosum.

*Fig. 9.* Enlarged section of the lobus olfactorius. Compare also Plate II, *Figs. 1-4.*

*Fig. 10.* Portion of *Fig. 9*, enlarged.

*Fig. 11.* Frontal cross-section of the right hemisphere and corpora quadrigemina of the rat, for comparison with sections figured on Plate V.

*Fig. 12.* Cells from cortex of crus olfactorius at point indicated by *b*, *Fig. 12*. (.025 mm. long.)

*Fig. 13.* Small area from cortex of ventral surface of hemisphere, in sections passing through the front of the callosum. (*C. Fig. 8*.) x 170.

*Fig. 14.* Portion of cortex from ventral aspect of hemisphere, near median portion of the pyriform lobe at the level of the anterior commissure. (*Fig. 8 a*, Plate II.)

### PLATE II.

C. L. HERRICK.

*Fig. 1.* Longitudinal vertical section of anterior portion of hemisphere of *Arctomys*.

*Fig. 1a.* Portion of glomerular layer of olfactory nerve bundle.

*Fig. 2.* Portion of upper cellular layer of crus olfactorius.

*Fig. 3.* Section through the granular, ganglionic, and gelatinous layers of olfactory lobe.

*Fig. 4.* Horizontal section of anterior part of cerebrum, with olfactory bulb, *Arctomys*.

*Figs. 5-7.* Similar sections at successively higher levels as far as to the corpus callosum.

*Fig. 8.* Transverse section through the corpus callosum and anterior commissure.

*Fig. 9.* Section of part of fornix body.

*Fig. 10. (IIIc-13.)* Horizontal longitudinal section through the middle of the right hemisphere, passing through the corpus callosum and the hippocampal involution.

### PLATE III.

C. L. HERRICK.

Details from sections of preceeding plates.

*Fig. 1.* Portion of corpus striatum, x 25.

*Fig. 2.* Cortex near olfactory tract in transverse section at cephalic margin of corpus callosum.

*Fig. 3.* Portion of cortex near middle of median fissure in transverse section, half way from front to corpus callosum, x 165. The arrow indicates the direction of the surface. Two sorts of cells, centrifugal preponderating.

*Fig. 4.* Typical motor area. (VIa-24a) Giant or ganglion cell layer near median fissure. (Compare Fig. 7.) x 165.

*Fig. 5.* Similar motor area in VIa-7, in front of the corpus callosum, in about the middle of the superior surface. Only the upper layers. x 165.

*Fig. 6.* Deep layer of cortex of median fissure near the lower third of vertical diameter. x 165.

*Fig. 7.* Section entirely through the cortex of VIa-24, at same point as Fig. 4. x 86.

### PLATE IV.

C. L. HERRICK.

*Fig. 1.* Transverse section through the hemisphere near the middle of the corpus callosum, showing the position of the fornix body and descending tract of the fornix. Also the relations of the corpus striatum and optic tracts.

*Fig. 2.* Transverse section through the thalamus, to show the relation of the hippocampus, its commissure and the rearrangement of the white matter in the thalamus. A small fragment of the corpus striatum remains.

*Fig. 3.* Portion of a, Fig. 2, enlarged. Structure of the hippocampus.

*Fig. 4.* Portion of cortex along median sulcus, (d, Fig. 2.)

*Fig. 5.* Small area from thalamus at c, Fig. 2.

*Fig. 6.* Deeper part of lateral cortex, (Fig. 2b.) The cells apparently shaped, with the acute apical process median. Is this due to oblique section of pyramidal cells? ~~Flask-~~



## PLATE V.

C. L. HERRICK.

*Fig. 1.* Section somewhat cephalad from Plate IV, Fig. 2. The crossing of fibres from the paries of the thalamus to the hemisphere, is shown.

*Fig. 2.* Transverse section farther caudad, showing adhesion of the hippocampus with the corpus callosum, also the position of the descending fornix fibres near the medio-ventral portion.

*Fig. 3.* Transverse section of hemisphere at the caudad extremity of the hippocampus.

*Fig. 4.* The entire brain seen from the dorsal aspect. For results of electrical stimulation see page 38.

*Fig. 5.* The same viewed from the ventral aspect.

*Fig. 6.* Another brain dissected and laid open to display the corpora quadrigemina, thalamus, ventricles, etc.

## PLATE VI.

C. L. HERRICK.

This plate illustrates the distribution and arrangement of the cellular elements in the postero-median areas of the cortex.

*Fig. 1.* (IIIc-12a) Giant or ganglion cells from a transverse section of the right hemisphere near the posterior part of dorsal surface and near the middle of transverse diameter. Chiefly centrifugal cells; a few centripetal. Camera. Magnified about 165 diameters.

*Fig. 2.* (VIb-15e.) Portion of transverse section in front of infundibulum at a point about 5 mm. from median line, giant or ganglion cells from the area governing sphincter of eye-lids. Camera, x 165.

*Fig. 3.* (VIb-15f.) Cells from the same section and depth, but farther from the median line and hence in the sensory area. Camera, x 165.

*Fig. 4.* (VIId-6a) Portion from transverse section in advance of Fig. 1. showing the upper part of the cortex in the sensory area. The section appears to be a little in advance of exit of oculo-motor roots. Camera, x 165.

*Fig. 5.* (VIb-3a.) From a transverse section a little back of the chiasm. Extreme lower part of the lateral surface of cortex, near the sulcus and occupying same relative position as (VI-15d,) multipolar and centripetal cells of middle zone of cortex.

*Fig. 6.* (IIIId-16.) Section near the chiasm. Camera, x 165. Giant cells of motor area, x 250, 1-10 inch objective and camera.

*Fig. 7.* Opossum, at juncture of fibre layer and cortex, near median fissure, half way from crucial sulcus to front. Section longitudinal.

*Fig. 8.* (Vb-7a.) Radial longitudinal section taken with corpus quadrigeminum as a centre passing through a point midway between median fissure and

BULLETIN OF THE LABORATORIES

basal hemisphere, 2-3 mm. posterior to chiasm. Rabbit. Chiefly centripetal cells.

*Fig. 9.* (VIb-17a.) From a transverse section a short distance posterior to infundibulum. The portion figured lies about 12 mm. from the median line and extends from the white matter upward through the ganglionic layer.

*Fig. 10.* (VIb-20a.) Still further back near the middle of the exposed part of the cortex. The portion figured supplements Fig. 9, covering the upper part of the cortex to below the giant cells. Drawn to a scale without camera. A mixture of centripetal and centrifugal cells. (See Plate VII, Fig. 1a. From nearly the same area as Plate VII, Fig. 2.)

PLATE VII

C. L. HERRICK.

*Fig. 1.* Section through infundibulum shaded to indicate the distribution of centrifugal cells in the cortex. Cephalic surface of a section of right hemisphere.

*Fig. 2.* (VIb-20a.) Portion of a section through the pyriform lobe, exhibiting the centripetal variety of cells unmixed with centrifugal. At the lower curvature, however, both varieties occur.  $\times$  about 165.

*Fig. 3.* Portion of the same section near the middle of the arc of the upper surface in an area where both varieties of cells are commingled.

*Fig. 4.* Opossum. Section through entire cortex and hippocampus, transverse section in front of the anterior commissure. Six layers. I. Neuroglia layer. II. First nucleary zone, cells about .03 long, in the upper part fusiform, below pyramidal. III. First granular layer. IV. Giant cells .04-.045 long. V. Imperfect second granular layer. VI. Transition zone. VII. Fiber zone. (Slide 19.)

*Fig. 5.* Opossum. Section through hippocampus. (No. 33.)

*Fig. 6.* Opossum. 5 mm. in front of crucial sulcus and a little nearer the median side than the external. Deep layer of cells.

*Fig. 7.* Opossum. Slide 22. Deep cortical layer toward lateral  $\frac{1}{4}$  of superior surface. Corresponding to layer 4, of Fig. 4. Giant cells. Section transverse and just in anterior part of anterior commissure. Cells about .04 mm. long.

*Fig. 8.* Opossum. Slide 79. Longitudinal section near middle of hemisphere, half way between crucial sulcus and front giant cell layer.

PLATE VIII.

C. L. HERRICK.

*Fig. 1.* Section through one-half the thalamus just back of the infundibulum.

*Fig. 2.* Similar section through the anterior part of corpus quadrigeminum a very short distance back of the preceeding.

- Fig. 3.* Similar section a few hundredths of a millimeter farther caudad.  
*Fig. 4.* Portion of *Fig. 1*, enlarged. x 165.  
*Figs. 5-9.* Portions of *Fig. 2*, enlarged. x 165.  
*Fig. 10.* Portion of *Fig. 4*, enlarged. x 165.

## PLATE IX.

C. L. HERRICK.

*Fig. 1.* Transverse section through the anterior corpus quadrigeminum, at the point of the 4th (oculo-motor) nerve. *Ol.* Optic tract fibres. *As.* Aqueduct of Sylvius. *Pp.* Pes pedunculi. *R.* Roots of nerve IV.

*Fig. 2.* Section somewhat farther back. *Rph.* Raphe. *L.* Lemniscus bres.

*Fig. 3.* Section still further back, near the middle of the corpora quadrigemina.

*Fig. 4.* Section still farther back at the anterior margin of the pons.

*Fig. 5.* Section at the caudad margin of corpus quadrigeminum anterior.

*Figs. 6-7.* Transverse sections of corpus striatum in sections lying between *fig. 6*, and *Fig. 7*, of Plate I. More highly enlarged.

## PLATE X.

C. L. HERRICK.

*Fig. 1.* Longitudinal vertical section through the corpora quadrigemina, somewhat laterad from the ventricle. *tr.* Tract from the posterior commissure. *V.* Root of the trochlearis. *tr, IV.* Tract of the trochlearis near its nucleus. *IV. n. III.* The principal portion of the nucleus of the oculo-motor. *III.* Root of the oculo-motor. *Mb.* Meynert's bundle. Inferiorly, a portion of the pons is shown, while superiorly, the nates and testes are cut nearly medianly.

*Fig. 2.* Upper portion of the nucleus of the third nerve of the left side, (I c-15.)

*Fig. 3.* Lower portion of nucleus of third nerve.

*Fig. 4.* Nucleus of the trochlearis.

*Fig. 5.* Median portion of the right hemisphere of *Lepus Sylvaticus*, to indicate especially the position of hippocampal commissure. The section is somewhat oblique, *i. e.*, inclined from right ventral toward the left.

*Fig. 6.* Section of the medulla and cerebellum of the left side at the exit of the root of the facialis and abducens.

*Fig. 7.* Portion of transverse section of posterior median portion of hemispheres of *Blarina brevicauda*, short-tailed shrew, especially for the relations of the hippocampus and corpus callosum.

## PLATE XI.

C. L. HERRICK.

The figures of this plate are chiefly intended to facilitate a comparison of the brain of *Arctomys* with other animals.

*Fig. 1.* Median longitudinal section of the brain of a young raccoon, *Procyon lotor*. The interrupted character of the calloso-marginal convolution along its margin and the highly convoluted limbic region are noteworthy. The primitive condition seen in the lack of a curvature in the brain axis is more than compensated for by the backward projection of the cerebrum, nearly covering the compact and closely convoluted cerebellum. The relations of the scarcely arched corpus callosum, fornix, anterior commissure, thalamus, pineal body, and mesencephalon, are well shown in the figure.

*Fig. 2.* Dorsal surface of a raccoon of the same age. The figures indicate positions stimulated by the electric current as described in the text.

*Fig. 3.* Ventral surface of another specimen of the same age, somewhat shorter than when in natural relations. The peculiar relations of the olfactory and optic tracts are noteworthy. The mammillary bodies and the plainly indicated tracts of the medulla may also be noted. The position of the third, fifth, seventh, and eighth roots alone is indicated.

*Fig. 4.* Dorsal surface of cerebrum of adult raccoon, somewhat shrunken and distorted.

*Fig. 5.* Dorsal surface of cerebrum of a quarter grown pup. x, indicates a lesion resulting in slight motor disturbance of the hind leg of the opposite side.

*Fig. 6.* Ventral surface of the brain of a kitten. With eyes still closed.

*Fig. 7.* Dorsal view of the same brain.

*Figs. 8-11.* Transverse sections of the cerebrum of the raccoon. *Fig. 9*, 22 mm. back of anterior margin. *Fig. 10*, 36 mm. back of anterior margin and just back of the chiasm.

*Fig. 11.* Still near the posterior or occipital margin of the hemispheres.

*Figs. 12-14.* Sections of the brain of the rabbit, *Lepus sylvaticus*. *Fig. 12.* View of corpora quadrigemina and left hemisphere from behind.

*Fig. 13.* Section at the middle region, and

*Fig. 14.* Near the anterior of the hemispheres.

*Figs. 15-17.* Cellular structure of the brain of the opossum, *Didelphys*.

*Fig. 15.* Portion of the cortex in front of crucial sulcus near the median line.

*Fig. 16.* Cells from the hippocampal region. *Fig. 17.* An instance of anastomosis of co ordinate motor pyramids.

*Figs. 18-19.* Ventral and lateral views of brain of adult opossum.

*Fig. 20.* Transverse section of same brain at anterior commissure.

## PLATE XII.

C. L. HERRICK.

*Fig. 1.* Horizontal section of left hemisphere and thalamus behind the co ~~ro~~ <sup>po</sup>

callosum, where the peduncular fibres cross to the thalamus.

*Fig. 2.* Cells from the area marked 11, in *Fig. 6*.

*Fig. 3.* Cells from the hippocampal region of the ground hog, the ventricle being at the right, the transition into the hippocampus at the left, to show the two varieties of cells at the ventro-caudad part of the posterior cornu.

*Fig. 4.* Cells from the fornix body, corresponding to *b*, *Fig. 8*, Plate II. The cells are .021 mm. long.

*Fig. 5.* Brain of a second individual of *Arctomys* for comparison with *Fig. 4*, Plate V. One-half size.

*Fig. 6.* Transverse section of brain of a kitten, at the hippocampal commissure.

*Fig. 7.* Section of the cortex at 2, in the preceeding figure.

*Fig. 8.* Portions of the superficial, middle and deeper parts of the cortex, adjacent to the corpus callosum in the lobe marked 1, in *Fig. 6*.

### PLATE XIII.

W. G. TIGHT.

*Fig. 1.* A transverse section of the cervical region at the entrance of the second dorsal nerve root.

*a.* Nucleus of ventral cornu.

*b.* Neck of dorsal cornu.

*c.* Ventral median column.

*d.* Spinal accessory nerve.

*e.* Canalis centralis.

*f.* Ventral commissure.

*g.* Burdack's column.

*h.* Goll's column.

*Fig. 2.* A magnified view of the cells from the cervix of the dorsal cornu, *Fig. 1, b*.

*Fig. 3.* A magnified view of the motor cells of the ventral cornu, *Fig. 1, a*.

*Fig. 4.* A transverse section of the cervical region of the cord at the entrance of the first dorsal and exit of first ventral nerve roots.

*a.* Cervix of dorsal cornu.

*b.* Ventral cornu nucleus.

*c.* Ventro-lateral cell-group of ventral cornu.

*d.* Median aggregation of cells.

*Fig. 5.* Magnified view of cells from neck of dorsal cornu, *Fig. 4, a*.

*Fig. 6.* Magnified view of ventral median column of cross section of nerve fibres.

*Fig. 7.* Magnified view of cross section of nerve fibres from Goll's column, *Fig. 1, D*.

*Fig. 8.* Magnified view of cells from ventral cornu nucleus, *Fig. 4, b*.

*Fig. 9.* Magnified view of cells from the ventro-lateral cell group of ventral cornu. *Fig. 4, c*.

## PLATE XIV.

W. G. TIGHT.

*Fig. 1.* A transverse section of medulla at the first appearance of the decussation.

- a.* Entrance of small bundle of XIth nerve root.
- b.* Nucleus of ventral cornu.
- c.* Nucleus of dorsal cornu cervix, elevated.
- d.* Median nucleus.
- e.* Commencement of ventro-dorsal lateral nucleus.

*Fig. 2.* Magnified section of the olivary body *a*, as seen in Fig. 6, Plate XIV, *a*.

*Fig. 3.* Magnified view of a portion of *c*, Fig. 5, Plate XIV.

*Fig. 4.* Magnified view of *c*, Fig. 6, Plate XIV.

*Fig. 5.* Cross section of medulla at the decussation, just caudad to the olivary body.

- a.* Decussation.
- b.* Median nucleus.
- c.* Ventro-dorsal lateral nucleus.
- d.* Funiculus gracilis.

*Fig. 6.* Cross section of the medulla at the central part of the decussation.

- a.* Olivary body.
- b.* Ventro-dorsal lateral nucleus.
- c.* Decussation.
- d.* Ventral portion of the median nucleus, nucleus of the XIIth nerve.
- e.* Dorsal portion of the median nucleus, nucleus of XIth nerve.
- f.* Funiculus gracilis.

## PLATE XV.

W. G. TIGHT.

*Fig. 1.* Cross section of medulla at the entrance of the XIIth nerve root.

- a.* Nucleus of Xth.
- b.* Nucleus of XIIth.
- c.* Cuneate nucleus.
- d.* Portion of the formatio reticularis.
- e.* Nucleus of the raphe.
- f.* Entrance of the XIIth nerve root.
- g.* Olivary body.
- h.* Tubercle of Rolando.
- i.* Nucleus laterale.
- k.* Pyramid.
- l.* Restiform tract.

*Fig. 2.* Magnified view of Fig. 1, *a*, nucleus of Xth nerve.

*Fig. 3.* Magnified view of Fig. 1, *e*, raphe.

*Fig. 4.* Magnified view of Fig. 1, *d*, formatio reticularis.

*Fig. 5.* Magnified view of Fig. 1, *b*, nucleus of XIIth nerve.

*Fig. 6.* Magnified view of Fig. 1, *c*, a portion of cuneate nucleus.

## PLATE XVI.

W. G. TIGHT.

*Fig. 1.* Transverse section of the medulla at the entrance of a small bundle of the Xth nerve.

- a.* Entrance of the Xth nerve.
- b.* Nucleus of the Xth nerve.
- c.* Nucleus of the XIIth nerve.
- d.* Olivary body.
- e.* Pyramid.
- f.* Ventro-lateral nucleus.
- g.* Restiform body.
- h.* Raphe.

*Fig. 2.* Transverse section taken at the entrance of some fibres of the nerve Xth, root and first fibres of VIIIth nerve.

- a.* Nucleus of IXth nerve.
- b.* Nucleus of VIIth nerve.
- c.* Inner portion of VIIIth nucleus.
- d.* Restiform Body.
- e.* Internal reticular nucleus.
- f.* Pyramid.
- g.* Fibres from the VIIIth root.
- h.* Dorsal longitudinal bundles.

*Fig. 3.* A transverse section of the medulla at the entrance of the auditory VIIIth) nerve.

- a.* Nucleus of the VIIth nerve.
- b.* Deiter's nucleus in the peduncle of the cerebellum.
- c.* Nucleus of root of VIIth nerve.
- d.* Interior of VIII nucleus.
- e.* Nucleus of the raphe.
- f.* Restiform body.
- g.* Pyramid.
- h.* Dorsal longitudinal bundles.
- i.* Entrance of VIIIth nerve.

*Fig. 4.* Magnified view of (VI-e-1a), multipolar cells of the nucleus of the XIIth nerve.

*Fig. 5.* Magnified view of cells from Deiter's nucleus.

*Fig. 6.* A longitudinal section of the medulla taken parallel to the base at level of the Vth and VIIIth nerves.

- a.* Entrance of the VIIIth nerve.



- b.* Nucleus of root VIIIth nerve.
- c.* Root of Vth nerve.
- d.* Nucleus of Vth nerve.
- e.* Openings left by the removal of the fibre bundles of VI and VII.

## PLATE XVII.

W. G. TIGHT.

*Fig. 1.* A transverse section of the medulla, a little cephalad from *Fig. 3*, Plate XVI.

- a.* Entrance of VIIIth nerve.
- b.* Nucleus of VIIIth nerve root.
- c.* Deiter's nucleus.
- d.* Nucleus of Vth nerve.
- e.* Olivary body.
- f.* Genu of VIIth nerve.

*Fig. 2.* A transverse section of the medulla taken at the entrance of the VIIth and Vth nerves,

- a.* Entrance of the VIIth nerve.
- b.* Genu of the VIIth nerve.
- c.* Entrance of fibres of Vth nerve.
- d.* Nucleus of Vth nerve.
- e.* Olivary body.
- f.* Deiter's nucleus.
- g.* Internal nucleus of VIIIth nerve.

*Fig. 3.* A transverse section of the medulla and cerebellum taken at the entrance of the caudad bundle of the Vth nerve.

- a.* Fibres of Vth nerve.
- b.* Motor nucleus of Vth.
- c.* Sensory nucleus of Vth nerve.
- d.* Olivary body.
- e.* Cephalad extension of internal nucleus of VIIIth nerve.

*f.* Spur from Deiter's nucleus. *Fig. 3* is reduced somewhat below the size of the other figures in order to show the form and arrangement of the cross-section of the cerebellum.

*Fig. 4.* Magnified view of cells from the motor nucleus of Vth nerve, *Fig. 3 b.*

*Fig. 5.* A cluster of cells from the nucleus of the VIth nerve, *Fig. 2 d.*

## PLATE XVIII.

W. G. TIGHT.

*Fig. 1.* A transverse section of the medulla taken at the entrance of the Vth nerve.

- a.* Root of Vth nerve.

- b.* Motor nucleus of Vth nerve.
- c.* Sensory nucleus of Vth nerve.
- d.* Nucleus of pons.
- e.* Dorsal longitudinal bundles.
- f.* Pyramidal tract.

*Fig. 2.* Magnified view of cells from the olivary body. Plate XVII 4, Fig. 2.

*Fig. 3.* A transverse section of the medulla at the entrance of the fourth nerve. in the region of the valve of Vieussens.

- a.* Nucleus of the pons,
- b.* Cell cluster in the median gray mass.
- c.* Dense group of small cells in the median gray mass.
- d.* Decussation of IVth nerve.
- e.* Root of IVth nerve passing cephalad to its nucleus.
- f.* Dorsal longitudinal bundles.
- g.* Pyramidal tract.

*Fig. 4.* Magnified cells from the nucleus of the pons, (VI.c-28-a.)

*Fig. 5.* Magnified cells from central gray mass taken at *b*, Fig. 3.

*Fig. 6.* A longitudinal vertical section taken near the side of the medulla and embracing the lateral portion of the cerebellum.

- a.* Root of Vth nerve.
- b.* Inferior peduncle.
- c.* Root of VIIIth nerve.
- d.* Nucleus of VIIIth nerve.

*Fig. 7.* Magnified cells from the central gray mass, taken at *c*, Fig. 3.

## PLATE XIX.

C. L. HERRICK.

*Fig. 1.* Vertical longitudinal section of the hemisphere through the lateral part of the optic chiasm. *Pd.* Peduncular fibres in the corpus striatum. *Ac.* Anterior commissure. *Ol. tr.* Olfactory tract. *O. tr.* Optic chiasm. *γ.* Nucleus above the ventral tract. *z.* isolated tract in the thalamus. *c. st.* Stratum zonale. *Ftr.* Descending tract of the nates. *Np.* Peduncular nucleus. *V.* Upper nucleus of trigeminus. *Vi.* Lower nucleus of trigeminus. *VII.* Root fibres of facial nerve. *X.* Nucleus of auditory nerve.

*Fig. 2.* Horizontal longitudinal section at the level of the third roots and anterior commissure. Anterior portion from a section a little higher than the remainder. *C.s.* Corpus striatum. *a.c.* Anterior commissure. *o.t.r.* Olfactory tract. *f.* Fornix tracts. *Pd.* Peduncular tracts radiating to the corpus striatum. *f.* Fornix fibres passing dorsad. *c.g.* Corpus geniculatum. *III.* Nucleus of oculo-motor nerve. *IV.* Nucleus of pathetic nerve. *n.* Interpathetic nucleus. *Vi.* Motor nucleus of trigeminus. *B.c.* Bladder cells of trigeminus. *V.* Tract of trigeminus from aqueduct, etc. *VI.* Caudal nuclei of the trigeminus. *Vr.* Root fibres of trigeminus. *h.* Cut section of dorsal tract to hemispheres. See Fig. 1, *L. tr.*

BULLETIN OF THE LABORATORIES

*Fig. 3.* Cells from the pons nucleus near its caudad portion on the left side. The arrow points backward.

*Fig. 4.* A portion of the two nuclei of the fifth, corresponding to the point *Bc*, Fig. 2, but on the opposite side. *a* illustrates the motor, *b* the bladder cells. Both points backward. Both are drawn to the same scale with camera lucida as the section shown in part in Fig. 2.

*Fig. 5.* Cells from nucleus of facialis to show the processes.

*Fig. 6.* Semi-diagrammatic section perpendicularly through the four outer layers of the nates, including the outer part of the tectum.

## ERRATA.

- Page 25, seventeenth line from top, read County, instead Connty.  
 Page 25, fifth line from last, a period after abundant.  
 Page 25, fourth line from last, a comma after this.  
 Page 25, second line from last, read, *Prætus haldemani*.  
 Page 26, thirteenth line from last, read, *Allorisma consanguinata*.  
 Page 26, tenth line from last, read, *Spirifer striatiformis*.  
 Page 27, eighteenth line from top, read, 18 inches.  
 Page 27, eleventh line from last, read, *Syringothyris*.  
 Page 28, tenth line from top, read, *Hem. crenistria*.  
 Page 28, eighth line from last, read, *Syringothyris carteri*.  
 Page 28, last line, read, *Poisonomya*.  
 Page 29, fifteenth line from last read, *Syringothyris carteri*.  
 Page 29, fifth line from last, read, alternating shales.  
 Page 30, eighteenth line from last, read, *Syriopecten nodocostatus*, and  
     *Chænetes tumida*.  
 Page 30, last line, read, *Hemipronites crenistria*.  
 Page 31, twentieth line from last, read, *Solenomya cuyahogensis*.  
 Page 31, nineteenth line from last, read, *Macredon tenuistriata*.  
 Page 33, eleventh line from top, read, *Taxicrinus communis*.  
 Page 33, sixteenth line from top, read, *Decadocrinus pleias*.  
 Page 34, seventh line from top, read, *Palæoneilo truncata*.  
 Page 34, fourth line from last, read, *Prætus haldemani*  
 [The author of the papers, "The Waverly Group" and "Tabulated List of Fossils," not having read the proofs, should be exonerated from mistakes in typography.]  
 Page 38, 4th line from bottom. For *Protyon* read *Procyon*.  
 Page 41, 18th line from bottom. For *thalmus* read *thalamus*.  
 Page 42, 9th line from top. Reverse position of *commissure posterior*.  
 Page 45, 14th line from top. For *restiform* read *restiforme*.  
 Page 49, 1st word. For *arber* read *aber*.

# DENISON UNIVERSITY, GRANVILLE, OHIO.

---

Has a beautiful and healthful location; a large and able faculty, Classical, Scientific and English courses of study; Preparatory and Collegiate departments; a well organized Academy; a number of Free Scholarships; an excellent working Library; Laboratories and Workshop, with steam lathes, and iron and wood-working machinery; ample Chemical and Physical Apparatus; special provision for advanced students; facilities for original work in Science; good buildings and pleasant grounds; opportunities for self-help to students.

EXPENSES UNUSUALLY LOW.

Fall Term begins Thursday, September 18, 1890.

---

For Catalogues or further information, address

GRANVILLE, OHIO.

D. B. PURINTON,  
President.

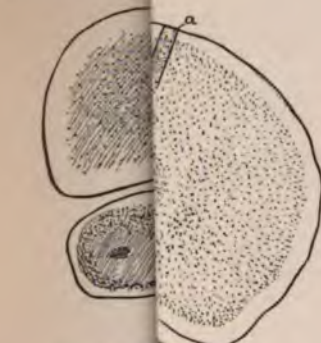


Fig. 5.



Fig. 9.

12.

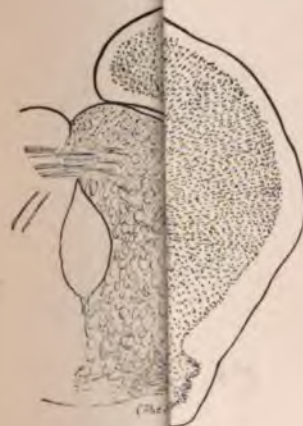


Fig. 7.



Fig. 6.

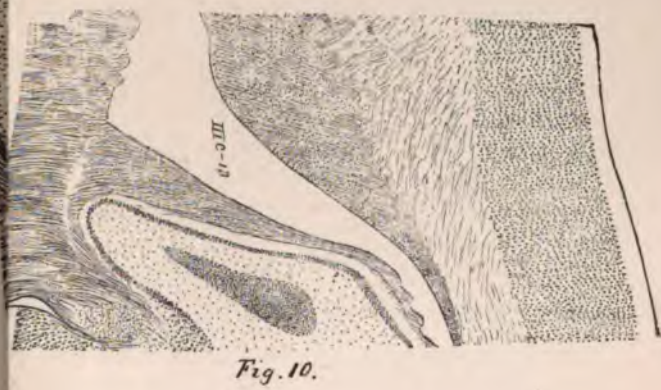


Fig. 8.

Wa-24.

THE NEW YORK  
PUBLIC LIBRARY  
ASTOR LENOX TILDEN FOUNDATION  
NEW YORK





THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS

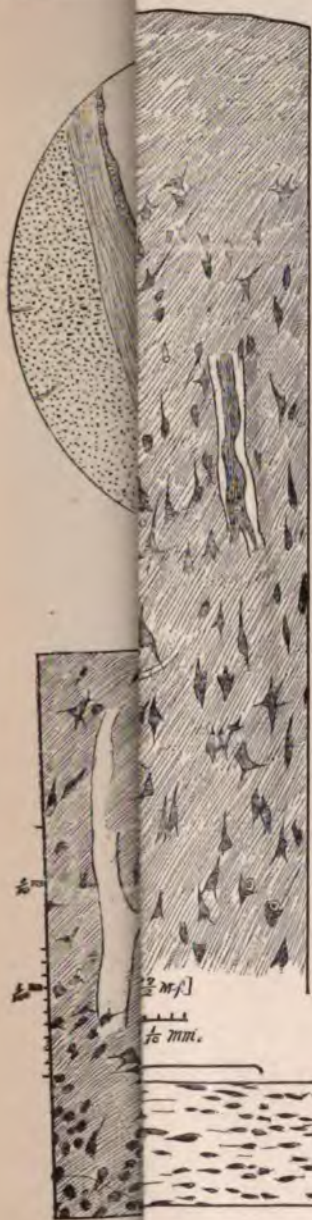
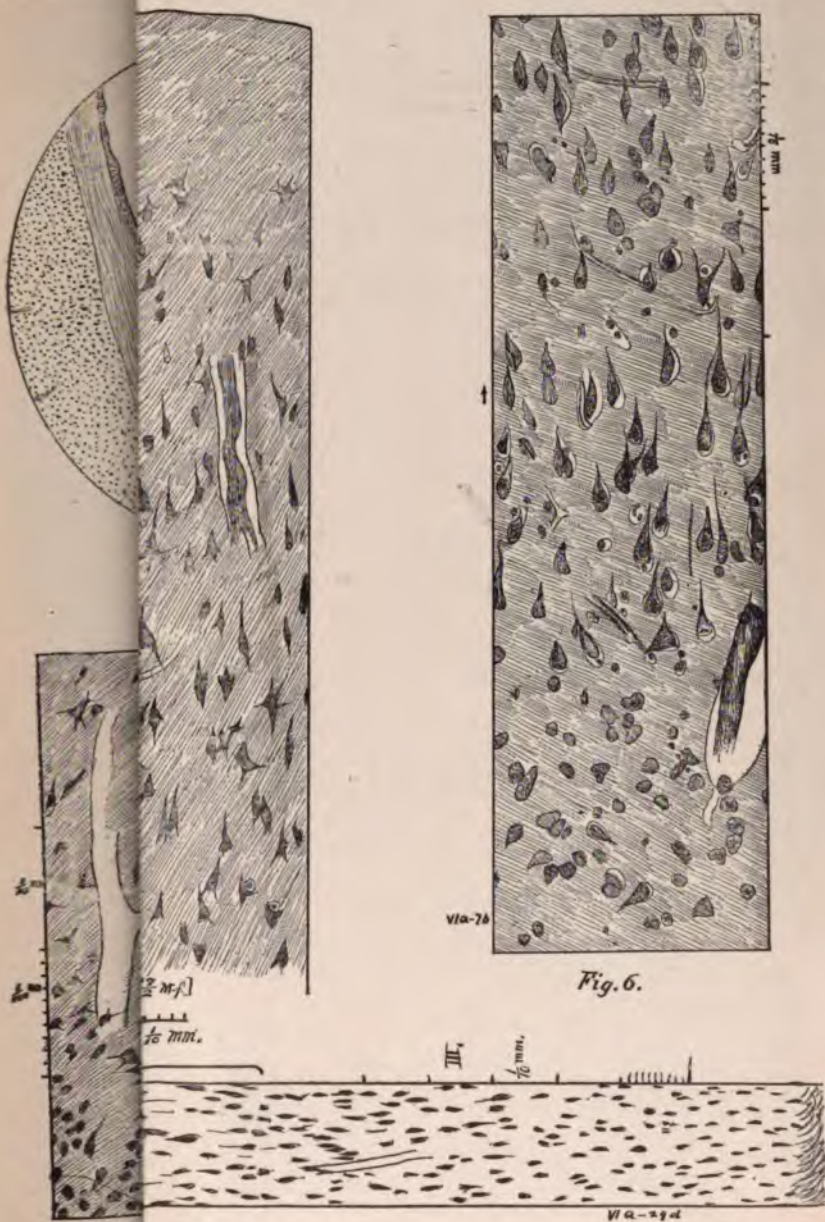


Fig. 6.







THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS.



Fig. 5.

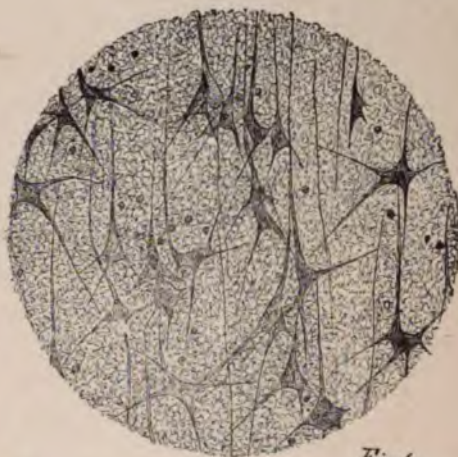


Fig. 6.



Fig. 7.



Fig. 8.



16-20a





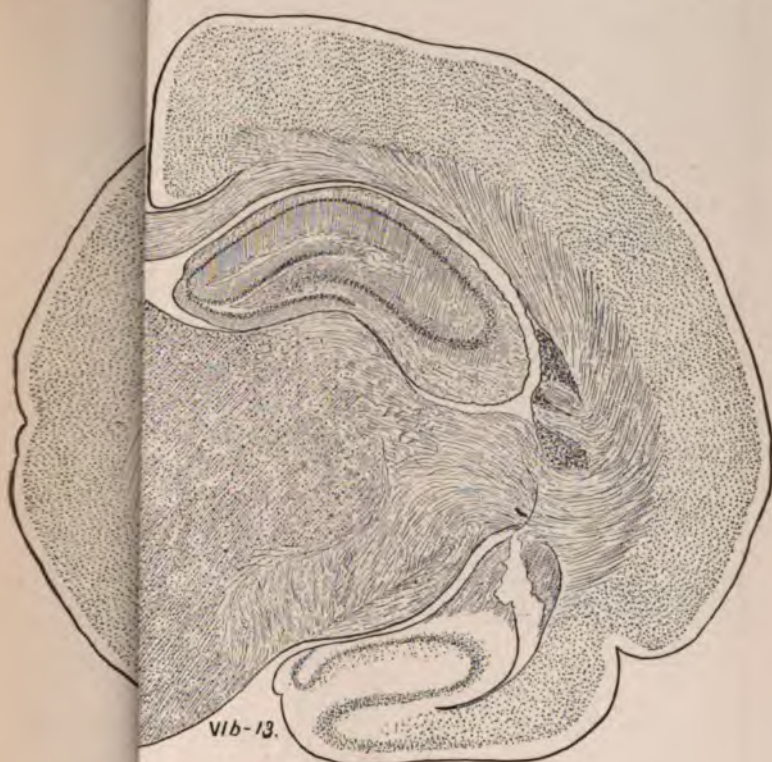
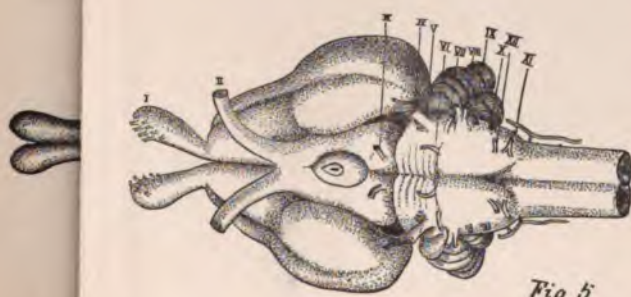


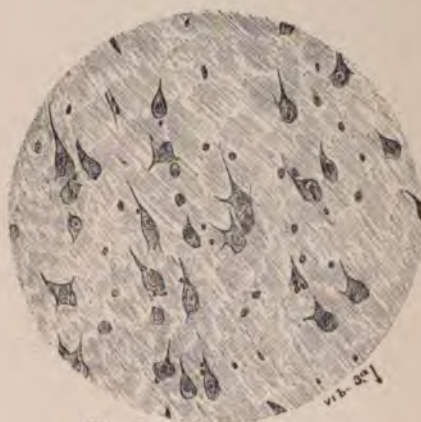
Fig. 1.



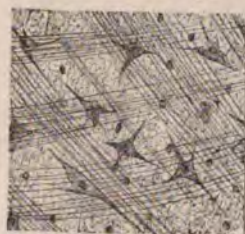
THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS.

Bu

Vol. V. Plate VI.



*Fig. 5*



*Fig. 7*



*Fig. 9.*

THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS.



*Fig. 1.*

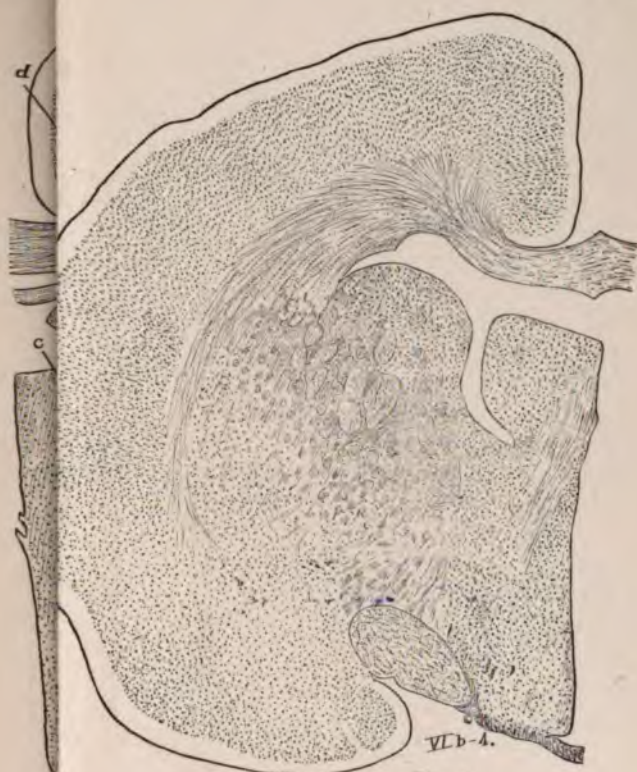


*Fig. 6.*

THE NEW YORK  
PUBLIC LIBRARY

ASTOR, LENOX AND  
TILDEN FOUNDATIONS.





*Fig. 1.*



*Fig. 6.*

THE NEW YORK  
PUBLIC LIBRARY



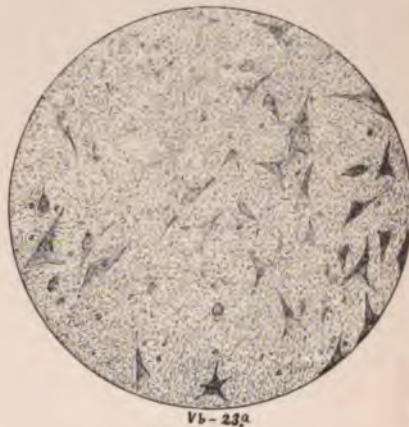
*Fig. 10.*



*Fig. 9.*



*Fig. 3.*

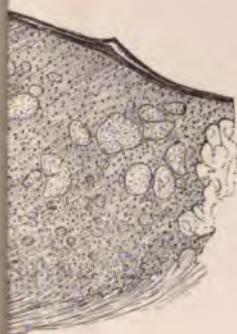


*Fig. 4.*

THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS



*Fig. 4.*



*Fig. 5.*







*Fig. 1.*



*Fig. 3.*



*Fig. 6.*



*Fig. 7.*



THE NEW YORK  
PUBLIC LIBRARY

ASTOR, LENOX AND  
TILDEN FOUNDATIONS.



Fig. 1

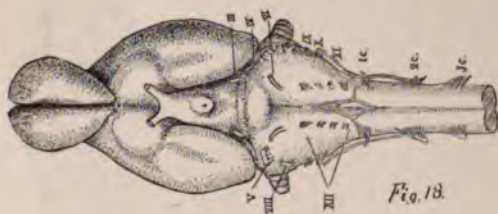


Fig. 18.



Fig. 19.



Fig. 6.



$1\frac{1}{2}$  Fig. 20.



Fig. 7.



Fig. 5.



Fig. 16



Fig. 17



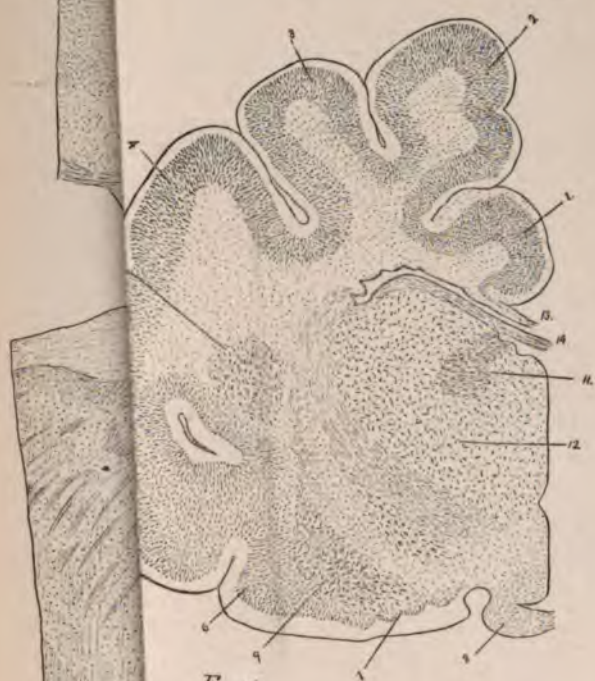


Fig. 6.

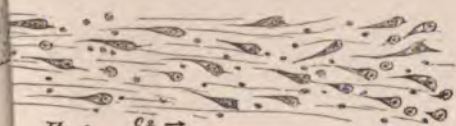


Fig. 7.

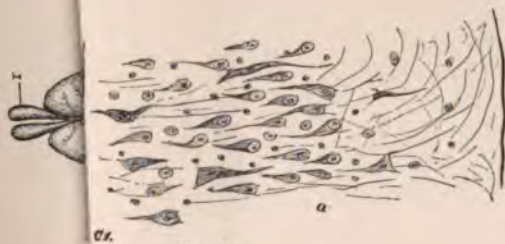


Fig. 8.

THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS.



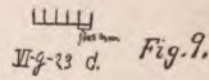
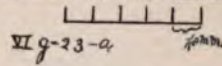
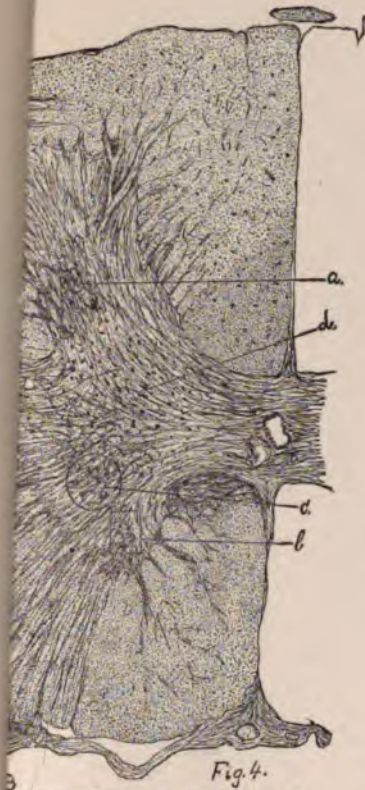








Fig. 3. VI-E-13-C

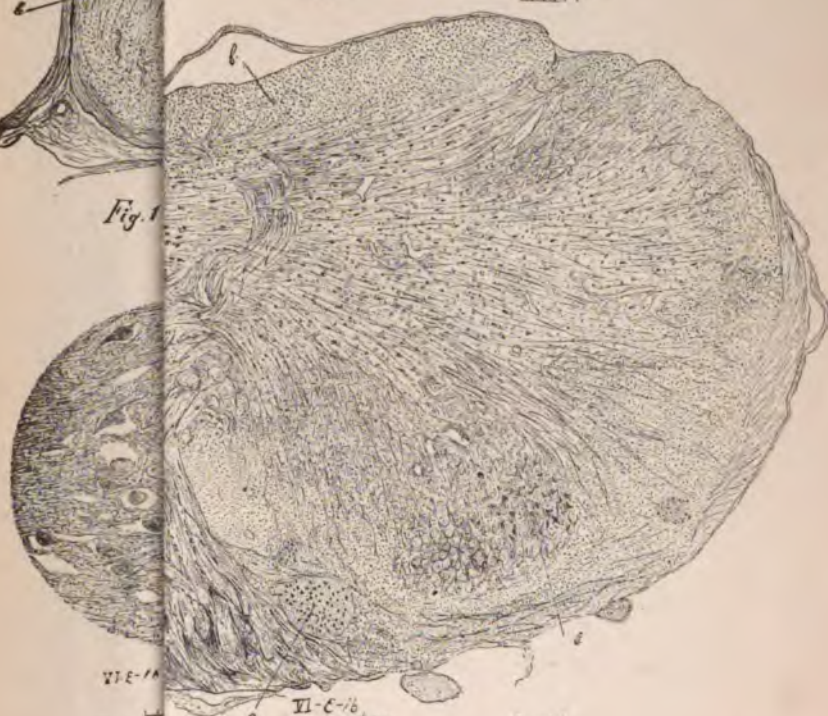


Fig. 4. VI-E-13-C

THE NEW YORK  
PUBLIC LIBRARY

ASTOR, LENOX AND  
TILDEN FOUNDATION

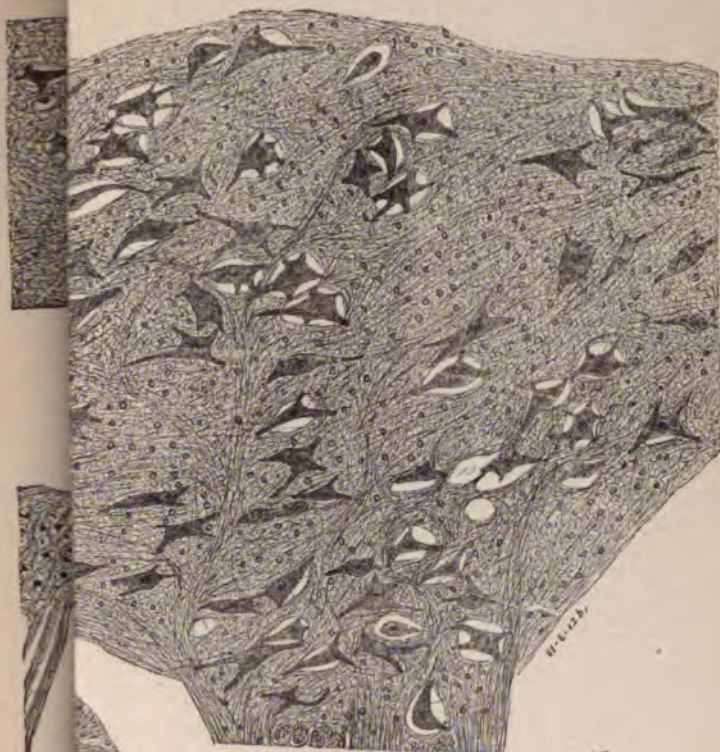


Fig. 5.



Fig. 6.

THE NEW YORK  
PUBLIC LIBRARY

ASTOR, LENOX AND  
TILDEN FOUNDATIONS.



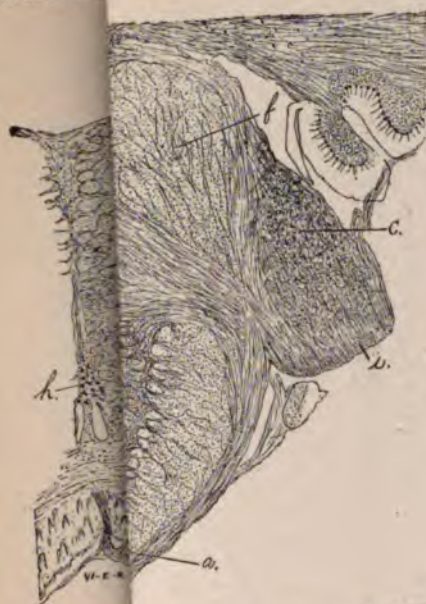


Fig. 1.



Fig. 3.



Fig. 4.

T  
P

THE NEW YORK  
PUBLIC LIBRARY

ASTOR, LENOX AND  
TILDEN FOUNDATIONS.

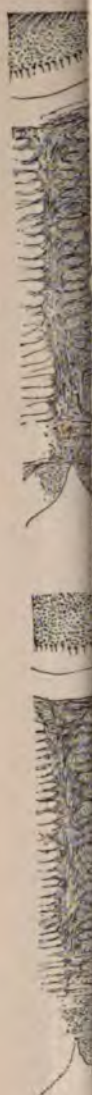


Fig. 4.

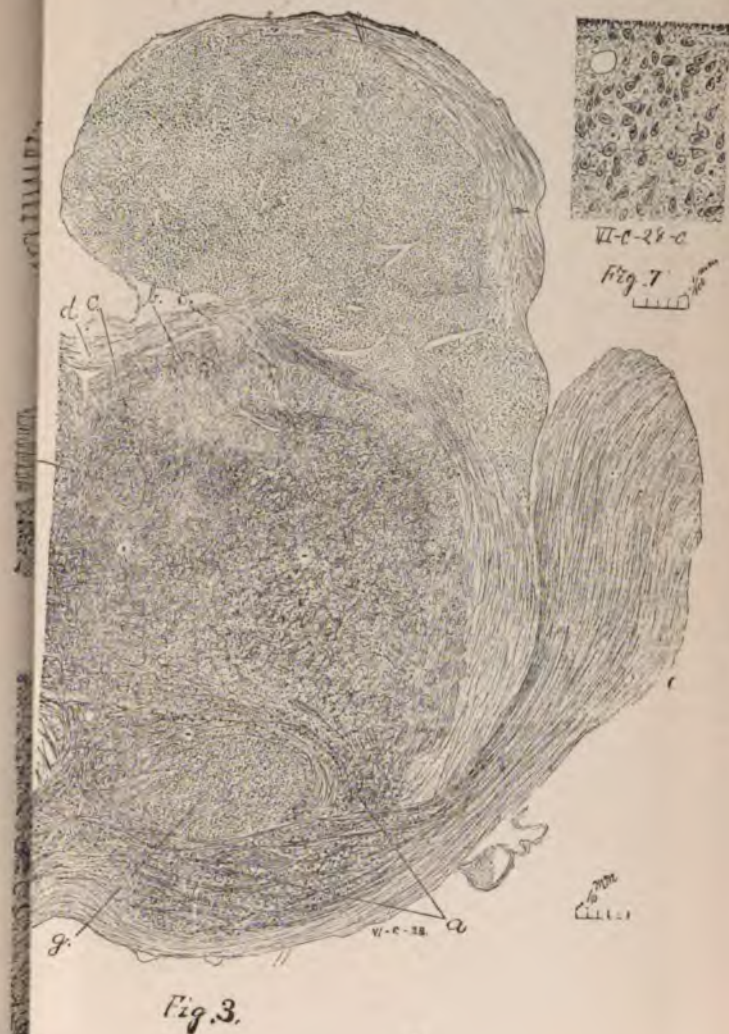


Fig. 5

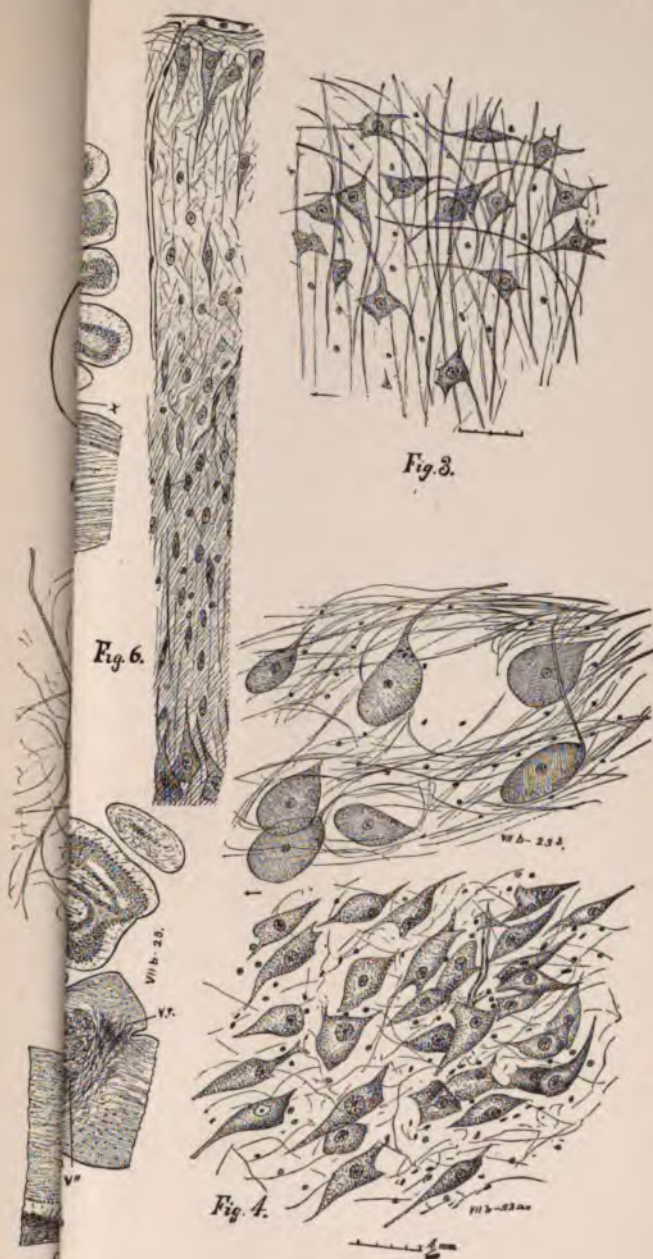
VI-C-904. 1/1000



THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS









1. The first part of the document is a list of names and addresses, which are arranged in a columnar format. The names are written in a cursive script, and the addresses are written in a more formal, printed style. The list is organized into two columns, with the names in the left column and the addresses in the right column. The names are: John Smith, James Brown, and William Jones. The addresses are: 123 Main Street, 456 Elm Street, and 789 Oak Street.

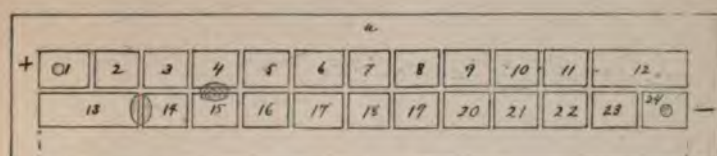


Fig. 1

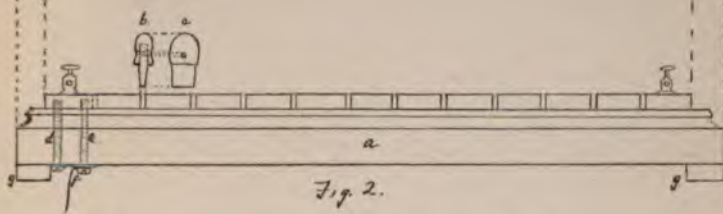


Fig. 2.

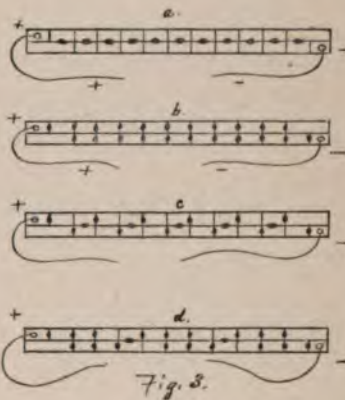
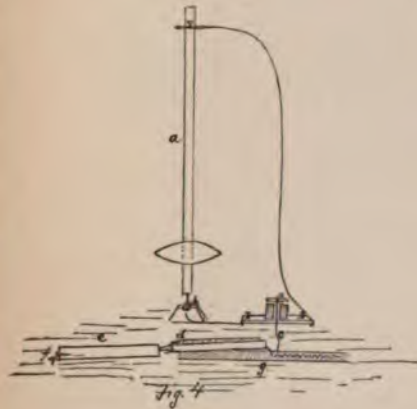
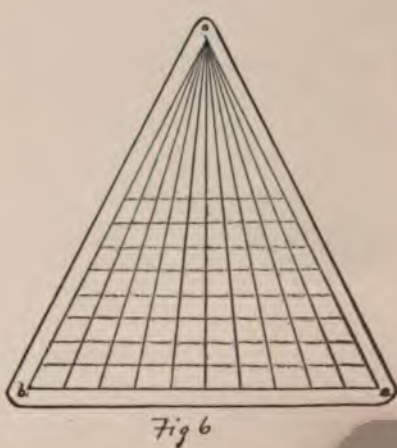
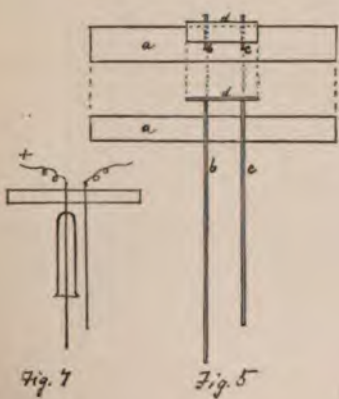


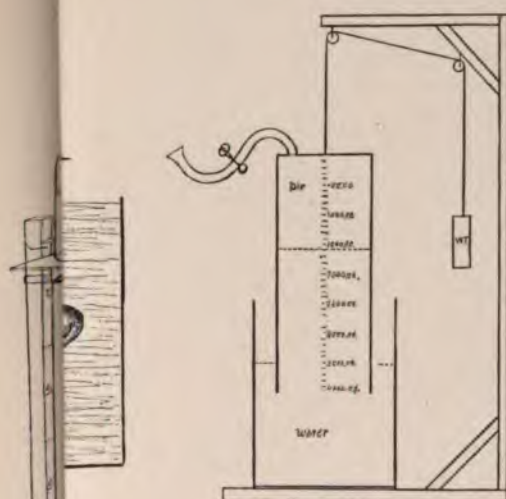
Fig. 3.



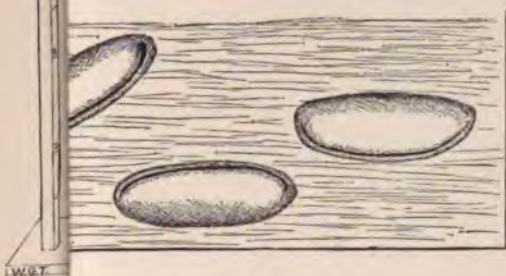








*Fig. 5.*



THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS.

BULLETIN  
OF THE  
Scientific Laboratories  
OF  
DENISON UNIVERSITY.

VOL. VI. PARTS I-II.

WITH TWELVE PLATES.

EDITED BY

W. G. TIGHT, M. S.,

DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

CONTENTS :

PART I.

|                                                                                                                                | PAGE |
|--------------------------------------------------------------------------------------------------------------------------------|------|
| Editorial Statement.....                                                                                                       | 3    |
| of Universities, Societies, etc., with which the BULLETIN Exchanges.....                                                       | 4    |
| Observations on the Crushing Effects of the Glacial Ice Sheet,<br>Plates A to D. W. G. Tight.....                              | 12   |
| Geological Notes upon Fiber, Geomys and Erethizon.<br>C. L. and C. Judson Herrick.....                                         | 15   |
| Notes on the Topography of the Rodent Brain: Erethizon Dorsatus and<br>Geomys Baratus. Plates I to III. C. Judson Herrick..... | 26   |
| Geological Observations at Granville.....                                                                                      | 47   |

PART II.

|                                                                                                                                              |    |
|----------------------------------------------------------------------------------------------------------------------------------------------|----|
| Notes upon the Cladocera, Copepoda, Ostracoda and Rotifera of Cincinnati,<br>with Description of New Species. Plates I-II. C. H. Turner..... | 57 |
| Cerebrum and Olfactories of the Opossum, Didelphys and Virginia.<br>Plates A, B and C. C. L. Herrick.....                                    | 75 |

GRANVILLE, OHIO, JANUARY, 1892.



Barnes'  
Patent  
Foot  
Power  
Machinery

FOR THE ACTUAL

## BUSINESS OF THE WORKSHOP

Outfits complete  
for Schools of In-  
dustrial Training—  
with them a Practi-  
cal Journeyman's  
Trade, in wood or  
metal, can be ac-  
quired. Illustrated  
catalogue free.

Address



W. F. & JOHN BARNES CO.,

179 RUBY STREET,

ROCKFORD, ILL.

BULLETIN  
OF THE  
Scientific Laboratories  
OF  
DENISON UNIVERSITY.

VOL. VI. PARTS I-II.

WITH TWELVE PLATES.

EDITED BY

W. G. TIGHT, M. S.

DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

CONTENTS :

PART I.

|                                                                                                                                    | PAGE |
|------------------------------------------------------------------------------------------------------------------------------------|------|
| Editor's Statement.....                                                                                                            | 3    |
| List of Universities, Societies, etc., with which the BULLETIN Exchanges.....                                                      | 4    |
| Some Observations on the Crushing Effects of the Glacial Ice Sheet.<br>Plates A to D. W. G. Tight.....                             | 12   |
| Biological Notes upon Fiber, Geomys and Erethizon.<br>C. L. and C. Judson Herrick.....                                             | 15   |
| Studies in the Topography of the Rodent Brain: Erethizon Dorsatus and<br>Geomys Bursarius. Plates I to III. C. Judson Herrick..... | 26   |
| Meteorological Observations at Granville.....                                                                                      | 47   |

PART II.

|                                                                                                                                           |    |
|-------------------------------------------------------------------------------------------------------------------------------------------|----|
| Notes upon the Cladocera, Copepoda, Ostracoda and Rotifera of Cincinnati, with Description of New Species. Plates I-II. C. H. Turner..... | 57 |
| The Cerebrum and Olfactories of the Opossum, Didelphys and Virginica.<br>Plates A, B and C. C. L. Herrick.....                            | 75 |

GRANVILLE, OHIO, JANUARY, 1892.

1397

THE JOURNAL  
OF  
Comparative Neurology

— AN —

*Illustrated Magazine Published Quarterly.*

DEVOTED TO THE  
Comparative Study of the Nervous System.

*Subscription, \$5.00 per Year.*  
After October, 1893, published at University of Chicago.

EDITED BY  
C. L. HERRICK,  
Professor of Biology, etc., of the University of Chicago.

BULLETIN  
OF THE  
Scientific Laboratories  
OF  
DENISON UNIVERSITY.

---

*VOL. VI. PART I.*

WITH SEVEN PLATES.

---

EDITED BY  
W. G. TIGHT, M. S.,  
DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

---

GRANVILLE, OHIO, MAY, 1891.



THE JOURNAL  
OF  
Comparative Neurology

— AN —  
*Illustrated Magazine Published Quarterly.*

DEVOTED TO THE  
Comparative Study of the Nervous System.

*Subscription, \$3.00 per Year.*  
After October, 1892, published at University of Chicago.

EDITED BY  
C. L. HERRICK,  
Professor of Biology, etc., of the University of Chicago.

## EDITORIAL STATEMENT.

---

WE desire to take this opportunity to extend our thanks to our numerous friends who have contributed to the museum of the Association and to its library; to those also who have contributed largely to the support of this publication; to Mr. E. S. Clark for a fine collection of plants and sea algae from Colorado and the Pacific coasts respectively; to Mr. J. Sanford for a collection of fishes from Lake Erie; to the University of Heidelberg, O., for a fine set of geological casts for the section of geology, and to numerous scientific societies and institutions, which, by their generous exchanges, have increased the value of our library.

It has been found necessary to postpone the publication of one of the articles intended for this volume until the close of the year, so that more time might be had for work, therefore this volume will appear in two parts.

## EXCHANGE LIST.

---

The following is the list of universities, academies, societies, individuals, etc., which make equal exchange with The Bulletin of the Scientific Laboratories of Denison University, and to which the Denison Scientific Association expresses thanks for many and valuable additions to its library.

Others who desire to make exchanges with the Association for its Bulletin, will please address the Permanent Secretary of the Denison Scientific Association, Denison University, Granville, Ohio.

### AMERICA (NORTH.) UNITED STATES.

ALBANY, N. Y.,  
State Library.

AMHERST, MASS.,  
Amherst College, Scientific Department.

BALTIMORE, MD.,  
Biological Laboratories.  
Johns Hopkins University.  
Journal of Psychology.

BOSTON, MASS.,  
American Academy of Arts and Sciences.  
Public Library.

BLOOMINGTON, IND.,  
Indiana University.

BROOKVILLE, IND.,  
Brookville Society of Natural History.

CAMBRIDGE, MASS.,  
Museum of Comparative Zoology.  
Peabody Museum of American Archæology and Ethnology.

CHAMPAIGN, ILL.,  
State Laboratory of Natural History.

UNITED STATES—CONTINUED.

- CHAPEL HILL, N. C.,  
Elisha Mitchell Scientific Society.
- CINCINNATI, O.,  
Society of Natural History.
- COLUMBUS, O.,  
Meteorological Bureau.  
Geological Survey.
- COLUMBIA, MO.,  
State University.
- CRAWFORDSVILLE, IND.,  
Botanical Gazette.
- DAVENPORT, IA.,  
Davenport Academy of Natural Sciences.
- IOWA CITY, IA.,  
State University Laboratories.
- INDIANAPOLIS, IND.,  
Geological Survey.
- ITHICA, N. Y.,  
Cornell University.
- LINCOLN, NEB.,  
Nebraska, University.
- MADISON, WIS.,  
Natural History Society of Wisconsin.
- MERIDEN, CONN.,  
Scientific Association.
- MILWAUKEE, WIS.,  
Public Museum.
- MINNEAPOLIS, MINN.,  
Academy of Natural Sciences.  
American Geologist,  
Geological and Natural History Survey.  
University of Minnesota.
- NEW HAVEN, CONN.,  
Connecticut Academy of Arts and Sciences.

## UNITED STATES—CONTINUED.

## NEW YORK, N. Y.,

Academy of Science,  
American Museum of Natural History.  
Microscopical Society,  
Torry Botanical Club.

## PHILADELPHIA, PA.,

Academy of Natural Science.  
American Philosophical Society.  
American Naturalist.

## ROCHESTER, N. Y.,

University of Rochester.

## SALEM, MASS.,

Essex Institute.  
Peabody Academy of Science.

## SAN FRANCISCO, CAL.,

California Academy of Science.

## SPRINGFIELD, MASS.,

Historical Library.

## SPRINGFIELD, ILL.,

Geological Survey.

## ST. LOUIS, MO.,

Academy of Sciences.  
Botanical Garden.

## TOPEKA, KAS.,

Washburn Laboratories of Natural History.

## TUSCALOOSA, ALA.,

Geological Survey.

## TRENTON, N. J.,

Trenton Natural History Society.

## WASHINGTON, D. C.,

Geological Survey.  
United States National Museum.  
Philosophical Society.  
National Academy of Science.

AMERICA (BRITISH.)

CANADA.

MONTREAL (*Quebec*.)

The Canadian Record of Science.

Royal Society of Canada.

Natural History Society.

TORONTO (*Ontario*.)

Canadian Institute.

AMERICA (CENTRAL.)

MEXICO.

MEXICO,

Sociedad Mexicana de Historia Natural.

(*Mexican Natural History Society.*)

AMERICA (SOUTH.)

ARGENTINE REPUBLIC.

BUENOS AIRES,

Sociedad Científica Argentina.

(*Argentine Scientific Society.*)

BRAZIL.

RIO DE JANEIRO,

Museu Nacional (*National Museum.*)

ASIA.

JAPAN.

TOKIO,

Tokio Daigaku (*Imperial University.*)

AUSTRALIA.

NEW SOUTH WALES.

SIDNEY,

Linnean Society of New South Wales.

SOUTH AUSTRALIA.

ADELAIDE,

Royal Society of South Australia.

VICTORIA.

MELBOURNE,

Royal Society of Victoria.

Philosophical Institute of Victoria.

## EUROPE.

## AUSTRIA-HUNGARY.

GRATZ (*Styria*,)

Der Naturwissenschaftliche Verein für Steiermark (*Society of Natural Science.*)

PRAG (*Bohemia*,)

Kaiserliche böhmische Gesellschaft der Wissenschaften (*Royal Bohemian Society of Science.*)

WIEN (*Austria*,)

Kaiserliche Akademie der Wissenschaften (*Imperial Academy of Science.*)

## BELGIUM.

BRUXELLES (*Brussels*,)

Académie Royale des Sciences, des Lettres et des Beaux Arts de Belgique (*Royal Academy of Sciences, Letters and Fine Arts of Belgium.*)

Musée Royal d' Histoire Naturelle de Belgique (*Royal Museum of Natural History of Belgium.*)

## DENMARK.

KJÖBENHAVEN (*Copenhagen*,)

Kongelige Danske Videnskabernes Selskab (*Royal Danish Society of Sciences.*)

## FRANCE

## ANGERS,

Société d' Etudes Scientifiques (*Society of Scientific Studies.*)

CHERBOURG (*Manche*,)

Société Nationale des Sciences Naturelles et Mathématiques de Cherbourg (*Society of Natural Sciences and Mathematics of Cherbourg.*)

## NANCY,

Société des Sciences de Nancy (*Society of Sciences of Nancy.*)

## PARIS,

Société Zoologique de France (*Zoological Society of France.*)

Société Géologique de France (*Geological Society of France.*)

## ROUEN,

La Société des Amis des Sciences Naturelles (*The Society of the Friends of Natural Sciences.*)



## GERMANY.

BERLIN (*Prussia.*)

Königliche (Preussische) Akademie der Wissenschaften (*Royal Prussian Academy of Sciences.*)

BREMEN (*Germany.*)

Naturwissenschaftlicher Verein (*Society of Natural Sciences.*)

DRESDEN (*Saxony.*)

Gesellschaft f-Natur-und Heil-kunde (*Society of Natural and Medical Sciences.*)

## FRANKFORT-AM-MAIN,

Senckenbergische Naturforschende Gesellschaft (*Senckenberg Naturalists' Society.*)

GÖTTINGEN (*Prussia.*)

Königliche Gesellschaft der Wissenschaften (*Royal Society of Sciences.*)

HALLE-AN-DER-SAALE (*Prussia.*)

Kaiserliche Leopoldini Carolina Akademie der Deutschen Naturforscher (*Imperial Leopold-Carolus Academy of German Naturalists.*)

Naturforschende Gesellschaft (*Naturalists' Society.*)

HEIDELBERG (*Baden.*)

Naturhistorisch-Medicinischer Verein (*Society of Natural and Medical Sciences.*)

KONIGSBERG-IN-PRUSSEN (*Prussia.*)

Die Königlische Physikalisch Oekonomische Gesellschaft (*Royal Physico-Economical Society.*)

Jena Medicinisch Naturwissenschaftliche Gessellschaft (*Medical Natural Science Society.*)

MUNCHEN (*Bavaria.*)

Königlich-Baierische Akademie der Wissenschaften (*Royal Bavarian Academy of Sciences.*)

## GREAT BRITAIN AND IRELAND.

## ENGLAND.

## BRISTOL,

Naturalist Society.

## BATH,

Journal of Microscopical Society.

## ENGLAND—CONTINUED.

## CAMBRIDGE,

Philosophical Society.

## LONDON,

Geological Survey of the United Kingdom.

Patent Office Library.

## MANCHESTER,

Literary and Philosophical Society.

## IRELAND.

## DUBLIN,

Royal Dublin Society.

Royal Irish Society.

## SCOTLAND.

## EDINBURGH,

Royal Society of Edinburgh.

## GLASGOW,

Natural History Society of Glasgow.

## ITALY.

NAPOLI (*Naples*),Reale Academie delle Scienze Fiesiche e Mathematiche (*Royal Academy of the Physical and Mathematical Sciences.*)Società Reale Di Napoli (*Royal Society of Naples.*)

## LUGANO,

Société Helvetique des Sciences Naturelles (*Helvetian Society of Natural Sciences.*)

## ROME,

Officio Geologico (*Geological Office.*)

## SOLOTHURN,

Naturforschende Gesellschaft (*Society of Naturalists.*)TORINO (*Turine*),R. Academia delle Scienza (*Royal Academy of Science.*)

## NORWAY.

## CHRISTIANA,

Norske Geologiske Undersaegelse (*Norwegian Geological Survey.*)

RUSSIA.

MOSKVA (*Moscow*.)

Imp. Moskofskoie Obshchestyo-Ispytatetei (*Imperial Moscow Society of Naturalists.*)

RIGA,

Obshchestyo Iestestyo-Ispytatelei (*Society of Naturalists.*)

SANKT-PETERSBURG (*St. Petersburg.*)

Comiti Geologique (*Geological Society.*)

Institute des Mines (*Institute of the Mines.*)

SPAIN.

MADRID,

Real Academia de Ciencias de Madrid (*Royal Academy of Sciences, of Madrid.*)

SWEDEN.

LUND,

Acta Universitates Lundensis (*Royal University of Lund.*)

STOCKHOLM,

Kongligi Svenski Vetenskaps Akademien (*Royal Swedish Academy of Sciences* )

Sveriges Geologiska Undevsökning (*Swedish Geological Institute*)

UPSALA,

Kongliga Vetenskaps Societaten (*Royal Society of Sciences.*)

SWITZERLAND.

BASEL,

Naturforschende Gesellschaft (*Society of Naturalists.*)

BERN,

Naturforschende Gesellschaft (*Society of Naturalists.*)

## SOME OBSERVATIONS ON THE CRUSHING EFFECTS OF THE GLACIAL ICE SHEET.

W. G. TIGHT.

It has been our privilege to devote considerable time of late to the study of the drift deposits of Licking county, including also a study of the effects of the continental glacier in modifying the topography. This region offers a very interesting field for work, as it is located just on the limiting line marking the probable advance of the ice cap. Part of the county being beyond the margin of the ice, and part evidently effected by it.

While the work is intensely interesting, it is at the same time exceedingly difficult, due to the subsequent action of the waters of the Champlain and Terrace epochs, thus working over and destroying the glacial deposits, and also on account of the character of the rocks acted upon, which are of a soft character and easily affected by disintegrating forces, so that the direct action of the ice, such as glaciation and scoring, is entirely lost. A more extended account of the results of the work done on this subject will appear in some subsequent volume of the Bulletin. At the present writing we desire to call attention to a few observations made at different points in some of the numerous quarries of the county on the character of the disintegration, and we offer them at this time, with the suggestions which they have aroused in our mind, not as representing any finished work, but more to direct attention to the subject and elicit any criticisms and suggestions which may be offered, and to learn whether anything has been done in this direction, and if so, where the desired literature concerning it may be obtained. Any information on this subject will be thankfully received. Our attention was first directed in this line while on a little geological excursion with our class. We were struck with the peculiar fractured appearance of the waste or surface rock above the solid stone employed by the quarrymen. The first quarry studied is located a mile north of Newark. Plate A is from a photograph showing about half of the quarry, which is located near the top of a high hill about a hundred feet above the creek bed. The

rock is the common freestone used so extensively for foundation work and building purposes. In Plate A can be seen the face of the solid rock which is worked, and a considerable portion of the broken material above it. Near the center of the illustration will be seen a large block of the harder portion of the rock, which has its corner broken by quite a number of curved fracture lines nearly parallel to each other and making almost a perfect truncation of the corner. These broken portions have slipped quite a little on the block in a downward direction, as seen by the fine lamination lines, thus indicating that the fracturing force was from above in a vertical line or but varying slightly from the vertical, and that it was not lateral, else the motion would have been in the other direction. Plate B represents a view of the rocks above the quarried rock in the same exposure, but on a little larger scale. Here it can be seen the rocks are fractured into all kinds of forms, having all sorts of curved and irregular faces, and it is impossible to trace any continuous jointing or stratification planes. However, in the individual fragments it is evident that the planes of stratification have been functional in determining form. On the top of this hill was found a number of erratics, and on the south side of the hill is a large deposit of glacial drift.

The next quarry illustrated, is located about one and a half miles south of Newark, and was chosen because it was about on an equal elevation with the first, and the exposure can be identified as being of exactly the same geological horizon, by a thin layer of coarse grained sandstone which is present in both. If, however, we study the rocks in this quarry, as will be seen in Plates C and D, which are taken from different parts of the same exposure, we will find that they are broken largely in but two directions, one along the planes of stratification, which can be followed through the whole quarry, no matter how near we approach the surface, the other almost at right angles to the first, vertical or nearly so, and corresponding in direction to the joint planes of the underlying harder rock. It will be seen also in Plate D especially, that no matter how close the rocks may come to the surface at the side of the hill there is no apparent breaking over in concoidal fractures. We also notice that the disintegration depends almost entirely upon the varying composition of the individual strata. No erratics were found on top of this hill, although they were quite abundant in the proximate valley, and drift material is also abundant at the bases of the neighboring hills. Many

other minor points might be mentioned which bear on the subject, but as this is not intended as an exhaustive treatise, they will be omitted for subsequent consideration. The facts presented indicate that the rocks of one quarry, those represented by Plates A and B, have been subjected to a tremendous pressure, and the others have not, or at least not to such an extent. That the pressure in the first case was from a superposed burden and not a lateral force. And it is evident that the burden has been subsequently removed. We believe that the first named quarry was covered by the ice sheet, and that the second quarry considered was not so covered, and would suggest it as a possible means of determining the extent of the ice front in regions where the country rock is easily fractured and presented in erosion hills.

As far as our observations on other exposures have extended we think they sustain us in our views, those within the glacial region showing evident marks of fracture by superposed burden and those beyond the recognized limits showing no such evidence. From the curved forms of the fracture spoken of in Plate A, and shown in many other instances in a more or less decided manner, it has been suggested that data might be derived by which the thickness of the ice, or at least the amount of the breaking force might be determined. Apparatus is now under construction for studying the resistance of blocks of the rock of different dimensions to a crushing force, and the forms of the fractures produced. There are many difficulties to be overcome and many modifying influences, but it forms at least a very inviting field for investigation. The illustrations are all from photographs taken and prepared by the author.

VIEW OF A PORTION OF HORN'S HILL QUARRY, NORTH NEWARK, O.

PHOTO BY W. D. THART.







VIEW OF A PORTION OF HORN'S HILL QUARRY, NORTH NEWARK, O.

PHOTO BY W. G. TIDWELL.



THE NEW YORK  
PUBLIC LIBRARY

ASTOR, LENOX AND  
TILDEN FOUNDATIONS.



VIEW OF A PORTION OF THE SOUTH QUARRY, NEWARK, O.

PHOTO BY W. G. TIPTON.

THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS.

VIEW OF A PORTION OF THE SOUTH QUARRY, NEWARK, O.

PHOTO BY W. D. THUR.





THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS.



## BIOLOGICAL NOTES UPON FIBER, GEOMYS AND ERETHYZON.

BY C. L. AND C. JUDSON HERRICK.

It has been considered appropriate to prefix to the account by one of us of certain neurological peculiarities of the above mentioned rodents, a brief statement respecting their habits and some points in their anatomy more or less directly bearing upon their nervous structures. The three groups are widely separated, and yet have a number of curious similarities, or rather agree in certain differences from other rodents in a way which may serve to justify the comparison as well as the contrasting of the types selected.

The MUSKRAT, *Fiber zibethicus*, is sufficiently well-known to every one, and yet perhaps few are aware of the extent to which the animal adapts itself to the varying conditions of its environment. One who casually learned to know the water rat in one of our western states might pass many years in Ohio without recognizing the fact that the same animal abounds in Ohio, and under the changed conditions here prevailing adopts an almost wholly different method of life. It would be more accurate to say that in the cold North-west, with its luxur of small lakes and marshes, the monotonous career of the animal expands in conformity with the greater variety of aquatic stations.

The muskrat is a truly Arvicoline rodent, that is, its affinities are with the field mice rather than with the jumping mice (*Hesperomys*) or oriental rats and mice (*Mus*). Though, at first sight, very different from *Arvicola*, the chief differences in *Fiber* are such as are obviously adapted to aquatic habit. The long, laterally flattened, scaly and naked tail, small ears, obliquely set and fringed hind feet with webbed toes are all modifications induced by accommodation to aquatic habit. The dark brown fur is long, with a liberal admixture of long, stiff, glossy hairs of a darker color than the rest. The color and texture varies with the season and in early summer rats may be found with a curiously tufted or mottled pelage. There are six mammæ and strongly developed perineal glands which are responsible for the peculiar musky odor implied by the name. The secretion is

often used by trappers for the more expensive castoreum in preparing "scent" used in baiting traps.

As, already indicated, the habits of the muskrat are subject to considerable variation. Its usual home is a long burrow opening beneath the surface of the water and passing many yards into the bank, terminating in a cosy nest beneath the protecting roots of a tree. It is here that young are reared and from these burrows the entire family may be seen emerging at twilight to engage in swimming races, games of tag, and sportive contests upon the surface of the stream. The head and rudder-like tail alone project above the surface and the long V-like diverging ripples which are created by the rapid swimmer soon span the entire stream and stand out in bold relief as they catch the sky tints at sun set. In regions not frequented by man or sufficiently protected by trees long run-ways may be traced from these burrows into neighboring meadows or wheat-fields. The family is large and the appetite is extensive if not critical. Almost anything of a vegetable nature will be tolerated but the corm-like roots of rushes and the rhizomes of the water-lily as well as flag roots are relished. The frantic and grotesque haste with which the rat when disturbed rushes down the run way toward the water, oblivious to any obstacle, is very amusing and sometimes startling and may have given rise to the stories of fierce on-slaughts upon man. Young-man-afraid-of-his-shadow might readily consider himself beset as the excited rat comes crashing down his path regardless of everything but his destination. Nevertheless there seems to be considerable evidence that old "rogue" rats are decidedly irascible, and a worried mother rat may over-step the bounds of etiquette in defence of her young. The burrowing habits of the rat associate him with the cray-fish and other enemies of canals and dams. Even in the vicinity of a large city like Cincinnati large numbers are annually taken in the canal-banks for their skins, which, when in prime condition, bring 15 to 18 cents

The comparatively simple domicile above described is adequate for the southern states and flowing waters but in Wisconsin and Minnesota the conditions are very different. Nearly every quarter section has its small lake or pond and these pools are shallow and mostly filled with weeds. Here the muskrat finds congenial resorts. Even in the bleak prairies the sloughs and ponds fairly swarm with these furry denizens. Here the intense cold of winter freezes all standing water to a depth of over four feet so that the openings of the summer homes

of the rat are sealed for four or five months and he is forced to construct a building suited to the seemingly infelicitous and conflicting conditions. The house must extend above water to admit air; it must be deeply buried from the cold; it must connect with the water; it must contain food; the food should be growing or fresh; the house should afford protection from enemies and escape when attacked.

The solution of these problems might tax the ingenuity of the ablest mind, yet nature, by the use of the simplest materials under the guidance of natural selection, has solved every one. Let us watch the process and, I doubt not, learn a lesson of skill and patience. The situation is a shallow pool which is destined to freeze nearly solid. It is grown up with rushes and *Nuphar* or spatter dock, two plants which play an important part in the domestic economy of this animal, supplying him at once with food and building materials.

In the placid days of early autumn a pair of muskrats may be seen diving to the bottom and tugging and biting at the roots of the rush. After tearing them off, the rat collects four or five of the rushes, say four feet long, and swims with them to a spot selected over the deepest part of the pool. Here they are arranged in parallel order and carefully straightened. Then another mouthful is brought and placed across the first at right angles. The angles are bisected by other clusters until a circular raft is formed sufficiently strong to support the weight of the animal. Now the colony of rats sets at work in earnest. And all day long one or more rats may be seen on the platform apparently eating rushes. Closer inspection shows that they are biting rushes into short lengths to form the "filling" of the structure. The accumulation increases and its weight causes the raft to sink and a new series of long rushes is added. Thus repeatedly until sufficient material has been accumulated to rest on the bottom of the pond. All the previous weeks the rats seemed to make little progress, as the material sank as fast as lifted much above the surface. During the early stages a strong wind may ruin the work of weeks but the rats are never discouraged.

So far only vegetable matter has entered into the composition of the hut, but as soon as it begins to rise permanently above the water there is a change of method and the whole space about the lodge is cleared of vegetation. The rats dive to the bottom and pull up the rushes and water-lillies by the roots and build them into the structure with large masses of earth adhering. The bottom is deepened and

thus the danger of freezing solid is obviated. The earth is used in plastering the outside of the hut, though this is not systematically done. A curious habit we have occasionally observed is the thatching of the hut with the large water-lily leaves so overlapping and cemented with mud as to form an impervious roof. By this time the ice is beginning to form and the hut has settled as much as it will, being buoyed up by the ice. The rats now burrow into the house from near the bottom forming a passage in the form of a letter U inverted, the uppermost part being above the water level and here a small chamber is excavated. Run-ways are excavated beneath the ice to various parts of the pond. In the long excursions undertaken beneath the ice the rats are said to ascend to the ice and exhaust the lungs, permitting the expired air to absorb oxygen and then reinspire it. This we have never been able to observe. The roots of Nuphar are built into the house or are stored conveniently near for winter use. The great mass of vegetable matter soon begins to "heat" generating warmth enough not only to add to the comfort of the occupants of this curious home but to cause new sprouts to spring from the roots. The chamber is enlarged during the winter and the part removed serves to supply food in case of outside famine. The outer layer of mud freezes solid and forms an adequate defense against the wolves which might otherwise wage a war of extermination. There seems to be a certain reciprocity between the occupants of adjacent lodges, although the rats are jealous by nature and have not the communistic characters of the beaver, though no whit inferior to them as architects.

As to the statement commonly believed by woodcraftsmen in the West that the muskrat prearranges his hut in view of the length and severity of the coming winter we can offer nothing definitely. There is, however, a wide variation in respect to the size and structure of the huts and a general correspondence though by no means a universal one, between the huts built during a given season. An average hut is 6x10 feet in diameter at the water's edge and the size of the chamber varies from 18 inches to two feet.

THE POCKET GOPHER OR POUCHED RAT, *Geomys bursarius*, although abundant west of the Mississippi, is probably unfamiliar to most non-professional observers. This animal is nevertheless the representative of one of the most interesting and distinctive of North American mammals.

Being practically subterranean they are little exposed to interruption and from their habits little likely to spread rapidly, they multiply in favorable localities to an incredible extent and miles of meadow land are honey-combed by their burrows. Their natural habitat is moist sandy bottom or prairie land where vegetation is succulent and the soil yielding. A large river naturally forms an almost insuperable barrier to their distribution. The centre for the whole group is in the upper Missouri region and various species extend northward into the Saskatchewan region and southward into Mexico. The group does not extend much east of the Mississippi except in the Gulf States. The existing genera are closely related. In New England and the Middle States they are entirely absent. There are obvious resemblances in the various members of the *Geomyidae* to the field mice *Arvicolinae* especially in important cranial characters while a more superficial resemblance, due chiefly to the presence of cheek pouches, allies them with the pouched mice or *Sacomyidae*. There are many points of agreement also with the African mole rats (*Georychide*) which they more nearly resemble in their habits.

As just indicated, these low-bodied, rat-like, but densely furred animals are chiefly remarkable for the large fur-lined pockets extending from the shoulder to the sides of the mouth but opening entirely outside the buccal cavity. These pouches have special muscles and are used in carrying food which, in all the species, is stored in subterranean graneries.

The fur is dense and very soft and mole-like. The under fur is plumbeous and very fine. Superficially the color is a subdued but rich brown with a purplish or reddish reflection and a glossy brilliancy during life which is lost in the prepared skin. The head and middle of the back are darker brown. Beneath, the colors are much lighter becoming whitish on the feet, tail and lower lip. There is also a light spot on the nose and below the small muffle. The vibrissæ are thin and pale. The female is lighter. A peculiar phase of coloration not known to correspond to any seasonal or physiological condition, occurs in animals which are dark gray, almost black, and uniform throughout. In old individuals there is a considerable admixture of white hairs especially upon the head. In summer the feet and tail become nearly naked. In form the pocket gopher differs from the rat-like rodents in the large relative size of the head and shoulders as well as the fore feet. The body tapers rapidly backward and the hind

limbs are very small. The tail is short and tapering and nearly destitute of fur. The enormous fore feet have a greatly expanded palm with special cartilaginous support but these members are not laterally rotated and displaced, as in the moles. The lower surface of the palm has a decided ridge which is reinforced by stiff bristles, making a serviceable scraper as the two are pushed in front of the animal.

The habits being entirely subterranean with the exception of rare nocturnal forays, our acquaintance with the animal must necessarily be formed under unfavorable conditions. It is little wonder that when dragged ruthlessly from his home a prisoner in the jaws of a trap, the recluse-like animal produces an unfavorable impression. When thus brought into the blinding glare of the day light he throws himself back upon his haunches, elevates his head, and, half in fury, half in pain, gnashes his teeth and utters the aspirated sigh-like spit which is the only note of offense. Blinded by the light, he turns toward every sound and appears quite demented. But in the seclusion of his burrow or when once on friendly terms with his captor, he appears a very different creature. Perhaps we are the only persons who have had the opportunity to study the interesting habits of the *Geomys* in captivity. After a short time he becomes perfectly tame and an engaging pet. When first secured he ate sparingly of potato but evinced decided preference for leaves and rhizomes of red clover, seizing them in one fore paw, which was used as a pair of forceps by bringing the long claws in opposition to the callosity of the palm, and feeding himself gracefully. While eating he assumed a semi-erect attitude and arched the back much as the muskrat does. In eating a clover plant he always pursued the same method, beginning at one extremity and "feeding it into" the mouth rapidly and uniformly using now one fore paw, now the other. After the keen edge of the appetite was removed the animal began at once to stow food into his pockets, in doing which he reversed his former position and seemed to all but stand on his head, cramming in the leaves and roots with much celerity. The play of the jaws is ordinarily like that of a rat, but at times, when a large root was encountered the jaws were set in rapid motion so that the clicks made by the teeth blended in one uniform clatter. A similar habit has been noticed in several rodents, especially the porcupine. The only truly vocal sound was a sharp squeak if the hissing note of rage be excepted. Upon the smooth surface of the floor the motions seemed embarrassed and awkward. A small twine stretched



on the floor served to stop his course until he divided it with the teeth rather than step over it.

When placed in a vessel of fresh earth the *Geomys* seemed almost distraught. The smell of fresh soil acted as a powerful stimulant and the animal careened about before falling to violent digging which he carried on literally tooth and nail, biting the clods, rooting violently, and throwing back the earth with the feet. This, however, was but play, and it was only when given larger quarters that he began the excavation of a burrow in real earnest. The position in digging is with the hind feet well forward and the back strongly arched. The earth is thrown back with the fore paws, and, as it accumulates under the animal, the latter launches a vigorous kick with both hind feet in the most ludicrously earnest manner. After a considerable pile is thus formed behind the animal, he turns about and approximating the callosities of the two fore feet in front and with the claws well up, he pushes the mass before him by the action of the hind limbs until it piles up in front of him, and he looks like a diminutive earth scraper. It is in this way that the earth is brought to the surface and not in the pockets as often stated. The whole process is accomplished in the most brisk and business-like manner possible. Thus, in the habits of the animal we have the explanation of an osteological peculiarity of the wrist. There is a strongly developed bone (the falciforme) not found in many mammals which serves to support the callosity which in this case, as we have seen, serves both as a scraper and an aid in prehension. The most noticeable fault of the gopher is his gluttony. The amount he eats is alarming. Our pet seated himself calmly upon the knee and disposes of one grass stalk after another most vivaciously, eagerly seeking for more. Bread was especially desired and with a shrewd eye for the future the beggar would fill both pockets and when appetite and both pockets were filled he would empty the latter in a corner of his den and promptly return for more.

When given the liberty of the room, he set off in a curious canter but usually returned to be placed in the box, where he constructed a new nest every day. In the darkest portion he formed a nest of dry grass where the midday sleep was enjoyed. This siesta is very profound so that one could frequently remove him from the box before he awaked, which he did with a start and appeared to require some time to get his bearings.



In suitable localities one may trace the progressive extension of the burrow by the small hillocks of earth thrown up, often extending in an irregular line for many rods in a meadow. The digging is chiefly confined to the early summer and autumn, or after a long rain. Dry earth is difficult to manipulate and during drought the favorite food of the gopher is not to be secured. The hillocks resemble those of a mole but are much larger. The burrows are of two sorts, permanent run-ways and explorative or temporary burrows. The latter are near the surface and are closed off from the permanent burrow when completed. When such a burrow is made in a potato field it can be traced with the utmost regularity from hill to hill and the tubers are systematically removed and stored in large deep cellars. The amount which one family will carry off in a few days is all but incredible. The natural food consists of grass roots, especially the tender shoots of the red clover, and like plants. A curious provision against winter needs was frequently observed. The main run-way was provided with blind alleys at intervals, each of which was somewhat expanded at the end. Here a store of grass roots is accumulated in quantities varying from a pint to nearly half a peck. The amount seems to be intentionally limited so that the slight heating shall stimulate the roots to fresh growth, thus providing fresh supplies for the winter. Larger chambers are constructed for the tubers of *Helianthus*, etc.

It is probable that the animal does not drink. Current stories as to the digging of subterranean wells and the like being, so far as we could learn, fabrications. There is no evidence of hibernation though in the nature of the case it cannot be disproven. The female appears to perform most of the work of digging.

The gophers may be trapped by one familiar with their habits. When a fresh mound is found this should be opened so that direct day light falls into the burrow. Then a second opening is made along the trend of the passage about eighteen inches from the first. The opening is carried a few inches below the level of the run-way and in it a small steel trap is placed. The trap is carefully covered with light earth to the level with the run way and the light completely excluded from the second opening. The success of the plan depends upon the dislike of the gopher for light. He at once brings a fresh supply of earth to stop up the opening and being blinded by the light does not

observe the second excavation. If the latter presents any irregularity, however, he immediately deposits the load there and barricades the burrow at that point.

THE PORCUPINE (*Erethizon dorsatus*, L.) is familiar to everyone from pictures and yet few have had the opportunity to observe it in its home in the pine forests of the north. In fact there is little to attract or awaken interest except for the peculiar quill like modification of the hair. Although a true rodent its gait and habits strangely suggest the hog and earn for it its popular pseudonym. Its distribution is largely coincident with that of the northern pine forests, though it delights to feed in the lush vegetation of the meadows bordering the quiet rivers.

A visit to the pineries of north-western Wisconsin by one of us during midsummer of 1890 afforded especially good opportunities for the study of their habits. Here settlers are few and the beasts of the forest still hold almost undisputed dominion. The porcupines, however, seem to prefer the settlement, being apparently very social in their tendencies and almost devoid of fear. The settlers detest them for their predacious habits and general ubiquity. They often nest under the floors of the cabins, particularly if deserted, and after the settlers have turned in, they enter very unceremoniously, prying into every thing, filling the clothes of the men with quills and working woe with the pork and beans designed for breakfast. In one case a crew of lumbermen was summarily awakened to find that an inquisitive "porky" had crawled into bed with them. It is needless to add that the previous occupants did not stop to parley, but left him in undisputed possession. For these reasons the settlers usually dispatch them with clubs or axes, whenever they find them. This method is preferable to shooting, for, on the one hand, they are very fat and sluggish animals and rarely attempt to escape, and, on the other hand, their reptilian tenacity to life makes the effect of a rifle ball very uncertain.

An animal riddled with rifle balls will sometimes climb to the top of a tall tree to expire in its crest. Their perfect protection from their enemies of the forest is to be their ultimate destruction, for it has favored those structural and mental peculiarities which make them an easy prey to mankind. As the settlers take possession of their native woods, it is perfectly obvious that the porcupines are a doomed race, soon to be found, like the American Bison, only in parks and zoological gardens.

In the vicinity of the settlements they seem strictly nocturnal, coming out of their burrows at dusk and retiring into them again at daybreak. But deeper in the forest they may be seen sporting about their burrows or swinging in the tree-tops above them at almost any time of day. Though very awkward on the ground, they are excellent climbers and will mount the straightest pine trunk with the greatest agility, with, however, a ludicrous appearance of clumsiness and a clatter which can always be recognized. Members of the same litter (usually not more than two) appear to keep together during the first season, even after maturity, and may frequently be encountered after nightfall picking their way through the brush in single file with that shambling gait and peculiar squeaking cry which at once remind one of a litter of half-grown pigs, and which wins for them the common appellation of "quill pigs."

Later in the year we had an encounter with one under rather unusual circumstances. Quietly paddling in a birch canoe provided with a flaming torch in the bow, we were watching for the luminous eyes of deer, which in the brightly illuminated area, stood quaking at the sudden apparition, or stampeded and rushed up and down piping a warning note to the remainder of the herd.

Our attention was attracted by a peculiar clattering sound—evidently the teeth of some animal in rapid motion, but louder and more rapid than anything we had ever heard. The source of the sound we were for a time unable to make out, but it was soon betrayed by the sound of heavy feet and some clumsy animal approached the swampy shore and began to feed upon the new growth of arrow-head leaf (*Sagittaria*) with the same noisy clatter. A charge of heavy shot brought the animal to the water's edge where, to our surprise, it immediately took to the water and swam toward us in a decidedly vindictive mood. Twice we fired buck shot into it at yard range before it ceased its attempts to swamp us. The stomach of this animal contained nothing but the finely divided shoots of sagittaria. On the same night a second individual was shot which clambered to the top of a tall tree. It must not be assumed, however, that the porcupine is necessarily nocturnal. In the sunny afternoon they may be seen feeding in the meadows, using their four-clawed hands with awkward cleverness in bringing grass tufts within reach of the mouth. If alarmed they clamber under the overhanging bank, and, drawing the

body together with quills bristling, they lie in fancied security. Nor are they far wrong so far as other animals than man are concerned.

The porcupine offers great inducements to wild cat or panther, which, nevertheless, never tempt these animals to attack the quill pig except in greatest extremity. We have received specimens of *Lynx rufus* with the head filled with the quills, some of them even entering the orbit. Even the panther is sometimes destroyed by these barbed weapons.

While there is no truth in the current belief that the porcupine discharges its quills voluntarily, yet it appears that by lashing its tail it may lodge some of the barbs in the skin of its enemy. Once fastened, these quills strike inward with great pertinacity and every movement serves to propel them onward.

Although preferring succulent vegetation or the green inner bark of poplars, etc., the porcupine is, upon occasion, omniverous.

The taste of salt is greatly relished and pork skins and barrels in which brine has been kept are greedily eaten, even the slight saline taste imparted by the hands to oars and ax-helves attracts them, and the implements of the lumbermen often suffer from their teeth. The Indians regard them in their turn as delicate food and prize it highly, as we had occasion to learn in barter for a specimen.

The porcupine is a good swimmer, voluntarily crossing large rivers. Being so fat the body is relatively light and protrudes greatly above water.

It is stated by careful observers that during the very coldest weather these animals sometimes pass days and weeks swinging pendent in the tree tops, literally in a state of suspended animation.

The one or two young are brought forth in May and are proportionally larger than in any other rodent. Dr. Merriam mentions one which weighed over one and one-fourth pounds prior to birth, being  $11\frac{1}{4}$  inches long. A full grown male measures three feet in total length.

STUDIES IN THE TOPOGRAPHY OF THE RODENT  
BRAIN: ERETHIZON DORSATUS AND  
GEOMYS BURSARIUS.

By C. JUDSON HERRICK.

The design of the present paper is to contribute further details in the direction indicated by the article on the Central Nervous System of Rodents in Volume V of this Bulletin. The types chosen for these studies were selected partly because they represent groups very different from *Arctomys monax*, the type there discussed, partly because they seem to be aberrant members of the rodent stock and present striking peculiarities both in habits and in general structure. *Erethizon dorsatus* is our only North American representative of the *Hystri-  
cidae*. In spite of important structural differences, it is very similar to the European genus *Hystrix*, in which it was placed by Linnæus, and it seems to be connected with the European porcupines by geological remains.\* *Geomys bursarius*, the "pocket gopher" of the West, is widely separated from the other *Myomorpha* by its fossorial and nocturnal habit and the peculiarities of structure resulting from it. Points of more general interest with reference to these eccentric forms are discussed elsewhere in this number.

No attempt has been made to consult all the literature bearing on this subject. Works which have been especially helpful are noticed in connection with their respective topics.†

\*See J. A. Allen in "Monographs of North American Rodentia," Washington, 1877, p. 397.

†The following have been consulted for the general topography :

Krause, W., "Die Anatomie des Kaninchens," Leipzig, 1868.

Steida, L., "Studien ueber das Centrale Nervensystem der Voegel and Saeugethiere." Zeits. f. wiss. Zoologie, Bd. XIX.

Steida, L., "Studien ueber das Centrale Nervensystem der Wiebelthiere." Zeits. f. wiss. Zoologie, Bd. XX.

The brains were hardened for 24 hours in weak chrome-acetic acid, then passed gradually from 50 per cent. to commercial alcohol, as usual. All sections were stained by hand with Grenacher's hæmatoxylin. The tracts were brought out better by using the concentrated stain, making it quite intense. For the minute histology, however, much better results were secured by diluting the stain from four to six times its volume and applying it long enough to give only a faint color.

#### EXTERNAL FORM AND MEASUREMENTS.

*Erethizon dorsatus.* This brain differs greatly in general appearance from the usual rodent type. The narrow anterior extremity, passing into the olfactories, the compression at the Sylvian region, and the widely diverging flocculi, which give to the rodent brain its characteristic appearance are not obvious here. Judging from Owen's figures,\* there is a resemblance in these points to the beaver. The porcupine brain is much wider in proportion to the length of the hemisphere, but both are well filled out in front. The European porcupine, *Hystrix crista*, has these characteristics much more pronounced. If Owen's figures† be correct, the cerebrum is considerably wider in proportion to its length than that of *Erethizon*. The common American muskrat, *Fiber zibethicus*, also has a cerebrum which much resembles that of *Erethizon*.

*The Rhinencephalon.* The olfactories appear rather smaller than in most rodents and project only about three mm. beyond the hemispheres. This is due in part to the unusual development of the anterior portion of the hemispheres themselves, in part to the fact that the olfactory lobes are closely appressed to the hemispheres. The olfactory crus is flexed dorsad and laterad, so that the two lobes are flattened against the cephalo-ventral aspect of the hemispheres, which latter are also flattened at the same region. The two olfactory crura are in close contact, but the lobes diverge dorsally. This appression of the olfactory lobes may be due to the enormous development of the front part of the skull. The inflation of the skull in the region of the nasal cavities and above them could readily crowd so closely upon

\*R. Owen, "On the Structure of the Brain in Marsupials," Philosophical Transactions, MDCCCVII, p. 93, Plate V.

†"Comparative Anatomy and Physiology of Vertebrates," Vol. III, p. 110.

the brain cavity as to cause the projecting olfactory lobes to be reflexed. The olfactory bulb is about 6 mm. in diameter, narrowing posteriorly into the crus, and is thickly covered on the whole cephalic and ventral surface with the roots of the olfactory nerves.

*The Prosencephalon.* The general form is hemispherical, each cerebral lobe being flattened on the median and ventral aspects. The great development of the front part of the cerebrum is the most striking feature of the brain. The ventral surface is unusually flat and broad. The pyriform and postrhinal lobes are not high, giving this surface a very different appearance from that of the brains of the rabbit or Guinea-pig.

The dorsal surface of the hemispheres is unconvoluted; on their ventral surface the rhinalis and postrhinalis form a continuous and strong fissure running their whole length. The compression in the region of the Sylvian fissure so conspicuous in most rodents is here reduced to a minimum. No trace of the Sylvian fissure itself is noticeable on the dorsal aspect; it is however, described and figured by Owen\* in the case of *Hystrix cristata* as well marked, though short. But there is on the ventral surface a shallow, though well defined, fissure running from the chiasm laterad to the rhinalis, where it stops abruptly. The pyriform lobe thus sharply defined is about 15 mm. wide at the widest part opposite the hypophysis. Other small fissures on the ventral aspect are occasionally present, but very variable. On the median surface of the hemisphere the callosum is bounded on the dorsal and caudal aspects by the so-called callosal fissure. Passing ventrad from the splenium of the callosum the hippocampal fissure is well marked. Caudad to the hippocampal fissure is another small fissure passing caudo-dorsad to a point about as high as the splenium, apparently a suggestion of the splenialis. On the olfactory crus are two superficial tracts of lighter color; the smaller and shorter passes caudad and mesad, the other can be traced caudad and laterad as far back as the chiasm. Their relations are discussed in the paragraph on the internal topography of the rhinencephalon. The hippocampus is essentially as in *Geomys*, and under that head this region will be discussed, as the true relations are more easily traced in that type.

\*"Comparative Anatomy and Physiology of the Vertebrates," Vol. III, p. 110.



*The Diencephalon.* The thalami are larger in *Erethizon* than in *Geomys*, the cephalo-dorsal aspect being especially depressed in the latter case. They are somewhat dome shaped above, and each is covered on the dorsal aspect by the hippocampus as by a cap. The corpora geniculata are large and quite obvious superficially. The post geniculatum is more conspicuous in *Erethizon*; both are well developed in *Geomys*. The cinereum is a sub-elliptical body, with the cephalic end, which is bounded by the transverse fibres of the chiasm, flattened. Its lateral portions are not covered by the overlapping pyriform lobe as in the rabbit. The mammillary is unpaired, median, and but slightly elevated. It is separated from the rest of the cinereum by a special fissure. The hypophysis is attached at the centre of the cinereum. It is fungiform, 7 mm. long, 7 mm. wide, and 4 mm. high. The stipe passes obliquely caudo-ventrad into the caudal portion of the body of the hypophysis, which is separated from the cephalic portion by a deep fissure on the ventral aspect. The epiphysis is of the usual conical form, 4 mm. high. It is pigmented at the apex. The third ventricle passes up a short distance into the basal portion (Plate I, Fig. 3.)

*The Mesencephalon* is almost completely hidden, the cephalic members by the hemisphere, the caudal members by the cerebellum. The cephalic members are longer, the caudal members wider and higher. This arrangement is very different from that of *Arctomys*, in which the cephalic members are much larger and occupy the position of both members in these types. The caudal members are there crowded back to a position almost ventrad of the cephalic (cf. Vol. V, Plate XIX, Fig. 1.)

The crura cerebri stand out with great distinctness, being exposed to a point nearly as far cephalad as the attachment of the hypophysis. They are divaricated both cephalad and caudad, giving rise to a depression which is hour-glass shaped, the posterior area perforata, lying between the cinereum and the pons.

*The Epencephalon.* The cerebellum is subellipsoidal. The flocculus is rather large, but projects scarcely at all beyond the lateral lobe of the cerebellum, nor is it separated from this lobe by bony partitions, as in most rodents. It lies in a very shallow cavity of the skull in close contact with the adjacent parts of the cerebellum.

*The Metencephalon.* The medulla is obovate, about as long as wide. On the ventral surface the pons and pyramids are strongly

marked. The lateral columns are greatly enlarged ventrad to the clava, forming the area ovalis of Wilder. The relations of the dorsal columns and the structures on the floor of the fourth ventricle are shown by Plate I, Fig. 3. The funiculus gracilis and the funiculus cuneatus fuse at the region of the calamus scriptorius to form the clava, which is very large. The obex is also large, lying ventrad of the preceding. On the floor of the ventricle the fasciculi teretes are divaricated caudad by the projecting genua of the seventh nerve. The eminentia acustica are large and double, being divided into two portions by a longitudinal fissure. The striae medullares are hardly visible in *Erethizon*; in *Geomys* they are very large. The posterior peduncle of the cerebellum passes into the restiform tract in the usual way.

The cranial nerves are illustrated by Plate I, Fig. 6. The optic nerves are smaller than usual, 1.2 mm. in diameter, 1 cm. from their insertion. The third nerves are about the usual size, inserted 1 cm. caudad of the chiasm on the ventral aspect of the crura. The fourth nerves are very small, pursuing the usual course. The fifth is large, 3 mm. in diameter at insertion, rapidly flattening out to much wider. It has two roots. The median is ventral and smaller and crosses the other at the Gasserian ganglion. The sixth is small, inserted just caudad of the pons about 3 mm. from the meson. But one root is apparent. The seventh is inserted on the caudal margin of the pons laterad of the sixth. The eighth is inserted 1 to 2 mm. caudo-laterad of the seventh. There are two roots, which lie in very close contact. The ninth, tenth and eleventh are closely associated in their exit. The ninth is small and more easily separated from the other two. The tenth has several large roots which are hard to separate from those of the eleventh. The eleventh itself can be followed as a large strand as far back as the third spinal, and for at least two-thirds of this distance gives off frequent smaller fasciculi into the medulla and cord. The twelfth arises on the caudal aspect of the pyramids by about six roots.

*Measurements.* Total length, tip of olfactory to end of medulla, 46.5 mm.; olfactory to cerebellum, 33 mm., to pons, 29 mm., to hypophysis, 21 mm., to chiasm, 17.5 mm.; width of the two hemispheres, median, 35 mm., one-fourth distance from caudal end, 33.5 mm., three-fourths distance from caudal end, 32 mm.; length of crura exposed, 8 mm.; length of tuber cinereum, 7 mm.; width of tuber cinereum, 6.5 mm.; length of corpora quadrigemina, 7.5 mm.; width of



corpora quadrigemina, 9 mm., thickness of corpora quadrigemina through the crura, 11.5 mm.; thickness of hemispheres, 21 mm.; length of cerebellum, 15 mm.; width of cerebellum at the flocculi, 25.5 mm.; thickness of cerebellum, 13 mm.; length of flocculus, 7 mm.; length of medulla, 15.5 mm.; width of medulla, 16 mm.; thickness of medulla at pons, 10 mm.; cephalo-caudal width of pons, 5 mm.; width of cord at insertion of the third spinal nerve, 7 mm.

*Geomys bursarius*. This brain conforms very closely to the usual myomorphic type. The figures presented in Plate I show a close resemblance to that of a white rat, which is introduced for comparison, the most important differences being in the more closely appressed hemispheres, the rhomboidal cerebellum without projecting flocculi, the form and markings of the medulla, and the general compactness of the brain as a whole. The prominences on the ventral surface are more pronounced than in *Erethizon*. The general appearance is intermediate between that of *Erethizon* and that of the rabbit.

*The Rhinencephalon* is of the usual form. The short, club-shaped olfactory lobes project about 4 mm. beyond the hemispheres, and are 3.5 mm. wide and 5.5 mm. long on the ventral surface.

*The Prosencephalon* differs but little from that of the rat. Aside from the points already mentioned, the Sylvian fissure presents slight differences, being stronger and produced farther dorsad in the rat. In both cases it crosses the rhinalis. The rhinalis fissure, as in the rat, passes farther laterad than in *Erethizon* and is not so deep. The most noteworthy feature of the ventral surface is the prominent postrhinal lobe. The pyriform also appears more prominent than in *Erethizon*, partly because the ventral surface is not so flat, but recedes more abruptly at the sides.

The hippocampus, which is at best a complicated and troublesome region, is here reduced to very simple terms and it is hoped that the series of transverse sections in Plate III may materially aid in understanding its structure. The first description of the hippocampus in rodents which has come to my notice is that of Stieda.\* A condensed translation of his account of it in the mouse is here inserted for convenience of reference, as follows: The two hemispheres may be compared to a single hollow body, whose cavity is in communication with the third ventricle. This hollow body extends caudad over

\*Op. cit. Zeits. f. wiss. Zoologie, Bd. XIX.

the thalami, which thrust the adjacent ventral wall inward so as almost to fill the cavity. That part of the original cavity which is not thus lost is greatly reduced by the adhesion of the dorsal and ventral parts of the wall until only a narrow space remains on either side, the lateral ventricles. The portion of the lower wall which is invaginated appears, when the ventricle is opened, as an arched mass in its floor, the cornu ammonis. This lower wall is not simple, but is convoluted, forming a folded arch directed cephalad, stretched over the thalamus. Thus, imagine that the hollow body [secondary prosencephalic vesicle] has had the lower wall on either side driven cephalad by a fold springing from behind in the direction of the arch of the thalamus opticus (Plate III, Fig. 4, *a*.) By this process there arise a lamina superior and a lamina inferior cornu ammonis (Plate III, Fig. 3, *le* and *li*.) The terms are strictly applicable in only a part of the course of these bodies, since the relation of the two laminae is altered caudad, the upper becoming lateral, the lower median. [These two portions are parts of the gyrus fornicatus.] In comparing the Ammon's horn with other parts of the cortex a difference is obvious, especially in the inferior lamina, in that a second fold has taken place, intercalating a band of smaller cells than those of the remainder between the upper and lower laminae. This is the so-called granular layer, or tænia cinerea cornu ammonis of Volkmann [gyrus uncinatus, Plate III, Fig 3, *gn*.] The two cornua meet and coalesce to some extent in the median line. The connection between the two cornua is chiefly due to the confluence of the layer of fibres and of large cells of the superior lamina. Far cephalad the layers of large and small cells of the inferior lamina also coalesce. The fibres arising in the Ammon's horn of either side arch over the thalamus and converge behind the callosum where they separate from the cornua and plunge obliquely into that part of the substantia cinerea anterior caudad of the callosum and cephalad of the thalamus. "In the region of the anterior walls of the third ventricle these gradually diverging bundles disappear behind the anterior commissure. They obviously, therefore, form a longitudinal commissure of the anterior ventral part of the hemisphere, the substantia cinerea anterior, with the posterior portion of the hemisphere. In other words they constitute the fornix." Stieda recognizes two bundles of fibres in the cornu ammonis, one longitudinal, the other transverse, one passing to the callosum, the other to the fornix. In carnivora Stieda states that the gray matter of the two cornua is not confluent.



Reference to Plate III will render these statements of Stieda clear in spite of the condensed form in which they are necessarily presented. The first fold mentioned by him, the primary fold of the hippocampus (Plate III, *a*,) does not appear in transverse sections to be a mere fold, or fissure, springing from behind; but it is complicated by the fact that its dorsal portion is pushed much farther cephalad than its ventral. The latter only passes as far as the level of the corpus mammillare (Figs. 3 and 4.) Cephalad of this region the lamina next the lateral ventricle, which I have called lamina ectalis (the superior lamina of Stieda, Fig. 3, *le*,) is in direct continuity ventrally with the other, the lamina entalis (or lamina inferior of Stieda, Fig. 3, *li*,) The fact that the dorsal portion of the primary fold of the hippocampus appears in transverse sections to pass much farther cephalad than the ventral portion is due to the arched form of the hippocampus itself. By reason of this forward arch the caudal portion of the hippocampus appears in longitudinal section, the cephalic portion in transverse section in these figures. The laminæ ectalis and entalis together constitute the gyrus fornicatus. By means of this primary fold the hippocampus is pushed far cephalad under the callosum beyond the chiasm until it comes into direct continuity with the fornix body in the region of the lamina terminalis. The primary fold reaches almost to the end of the gyrus fornicatus, but in Fig. 1 has disappeared.

The true relations of the gyrus uncinatus are much more difficult to make out. It is formed, as Stieda says, by a secondary fold of the gyrus fornicatus; but it is not, like the primary fold, due to an invagination, or convolution. It is rather a reflected portion of the margin of the lamina entalis. This margin is folded back upon itself, the folded portion, i. e. the gyrus uncinatus, being reflexed ventrad and cephalad, so that the free margin of the latter lies next to the diencephalon and mesencephalon. The convexity of the fold is directed cephalad, and toward the caudal end of the hippocampus it apparently in transverse sections increases greatly in size. This appearance, however, is due to the arched character of the hippocampus by which the caudal portion is seen in longitudinal section, as above alluded to. That the gyrus uncinatus is a true fold from the gyrus fornicatus is not very obvious from these sections, since the gray matter of the two gyri is nowhere in direct continuity. Moreover the cell structure is essentially different, the gyrus fornicatus having typical flask-cells, but the gyrus uncinatus smaller deeply staining cells which

are narrowly flask-shaped or fusiform. The difference is emphasized in the sections by the fact that the gyrus uncinatus lies in a different plane from the gyrus fornicatus, and thus when the cells of the latter are cut longitudinally those of the former are almost always cut transversely. Perpendicular longitudinal sections of the mouse brain, however, show the two laminae in much closer contact, and in the opossum the continuity is unbroken, especially cephalad, though in the caudal portion the arrangement is more like that of rodents. Old embryos of the rabbit, too, show the formation of the folds above described with great clearness. The gyrus uncinatus in these rodents thus appears to be more or less displaced, as well as folded. In the rabbit embryos referred to it would appear to originate as a thickening on the free edge of the gyrus fornicatus, which is thrust back as by some external resistance, both on the ectal and ental surfaces of this edge, but chiefly on the latter. The cells which connect the two portions at this stage appear to be subsequently lost or to be replaced by fibrous elements.

The confluence of the gray matter of the two hippocampi, which Stieda describes in the case of the mouse, does not occur here. The external fibre zones of the two sides do come into contact in the meson, but this is obviously merely a mechanical adhesion. I suspect that the confluence which Stieda observed was more apparent than real, though my own mouse sections show the two sides in much closer contact than in *Geomys*. *Fiber zibethicus* resembles the mouse in this respect, and in the configuration of the hippocampus as a whole.

*Erethizon dorsatus* presents a structure essentially like that described for *Geomys*, though somewhat more difficult to follow. The chief difference lies in the gyrus uncinatus, which is larger and overlaps the free margin of the gyrus fornicatus much more than in *Geomys*. In *Arctomys monax* there is considerable variation, though only in the relative position of the parts. It is illustrated quite fully in Vol. V, Plate IV, Fig. 1, Plate V, Figs. 1, 2, and 3, Plate VII, Fig. 2, Plate X, Figs. 5 and 7, Plate XIX, Figs. 1 and 2.

*Diencephalon and Mesencephalon.* The relations here are essentially as in the rat. The thalamus is much smaller than in *Erethizon*, the cephalo-dorsal portion especially being abbreviated. The cinereum is nearly circular with the infundibulum passing through the centre. The chiasm is not so prominent as in *Erethizon*, though essentially

similar. The mammilare is single, median, and large, occupying the whole caudal part of the cinereum. The hypophysis and epiphysis were not observed. Both the prægeniculatum and the postgeniculatum are more prominent than in *Erethizon*, especially the latter. The caudal members of the corpora quadrigemina are covered by the cerebellum, the cephalic members are nearly covered by the hemispheres. The former are broader laterally, the latter are longer. They are of about equal height.

*The Epencephalon* is compact, like that of *Erethizon*, but very different in shape. The median lobe is produced farther both caudad and cephalad, thus making the cerebellum considerably longer, and giving it a decidedly rhomboidal shape when looked at from above. In the flocculus it resembles *Erethizon*, thus differing widely from other myomorphs, whose flocculi are longstalked and encased in special cavities of the skull.

*The Metencephalon* is oblong, about as wide as long. Ventrally the pyramids do not stand out in as bold relief as in *Erethizon*, neither is the pons as sharply defined. On the dorsal surface, the clava is not so wide as in *Erethizon*, being crowded mesad by the larger lateral columns. The obex is small, but sharply defined. The eminentia acustica is large and the striæ medullares are very conspicuous. The fasciculi teretes and other structures of the floor of the fourth ventricle are not so prominent as in *Erethizon*. With reference to the nerve roots, the most important peculiarity is the unusually small size of the second pair. This is readily accounted for by the small size of the eyes and the nocturnal habits of the animal. The fifth nerves are easily separable into three fasciculi before they enter Gasser's ganglia. Of these the middle bundle is the largest.

*Measurements.* Total length, tip of olfactories to end of medulla, 22.5 mm.; greatest width of the two hemispheres, 16.5 mm.; length of hemisphere, 13.5 mm.; depth of hemisphere, 10 mm.; tip of olfactory to cerebellum, 16 mm.; tip of olfactory to pons, 14.5 mm.; tip of olfactory to hypophysis, 12.5 mm.; tip of olfactory to chiasm, 10 mm.; length of cinereum, 5 mm.; width of cinereum, 5.5 mm.; length of cerebellum, 9.5 mm.; width of cerebellum, 13.5 mm.; depth of cerebellum, 7 mm.; length of flocculus, 4.5 mm.; length of medulla, 7.5 mm.; width of medulla, 7 mm.; thickness of medulla at pons, 5 mm.; width of spinal cord, 4.5 mm.



## INTERNAL TOPOGRAPHY.

In the following pages all statements apply both to *Erethizon* and to *Geomys*, unless otherwise indicated. Comparison was also made in many particulars with a series of sections of *Fiber zibethicus*.

*Ventricles.* The third ventricle is shown in its relations in median longitudinal section by Fig. 3, Plate I. The aqueduct of Sylvius is wide and there is a slight indication of a ventricle of the mesencephalon. The third ventricle is largely occupied by the mediodorsal commissure, particularly dorsally. Below, it passes into the infundibulum in the center of the cinereum. Cephalad of the chiasm there is another depression, which is superficially bounded by little more than a membrane. Dorsad, the third ventricle enters the epiphysis for a short distance. Cephalad of the mediodorsal commissure are the foramina of Monro, or portae, shaded black in the figure. The lateral ventricles of the hemispheres envelop the striata on the dorsal and median aspects. The *præcornua* arch as far laterad as the cephalic ends of the striata. From their cephalo-ventral limits the aqueducts of the olfactory ventricles push out into the olfactory crura. The olfactory ventricles, though small, pass almost to the ends of the olfactory bulbs. The *medicornua* of the lateral ventricles are strong, enveloping the hippocampi on their lateral and dorsal aspects.

*Olfactory Lobe and Tracts.* The minute structure of the olfactory lobe seems to be essentially that described for *Arctomys* in Vol. V of this Bulletin, page 81. The specific olfactory, or ganglion cells, however, are not usually pyramidal, but irregularly fusiform or flask-shaped, with the apices directed peripherad.

The arrangement of the olfactory tracts is about the same in *Erethizon*, *Geomys*, *Mus musculus*, and *Fiber zibethicus*. It can best be described in *Geomys*. Transverse sections of the olfactory bulb (Plate II, Fig. 4) show within the fibres of the olfactory nerves the usual glomerular layer containing sparse, small, pyramidal cells, a layer of ganglion cells in a single series, whose bases lie in a thin granular zone of Deiter's corpuscles. This zone is separated by another thin band of the neuroglia layer from the dense central mass of laminated Deiter's cells which fills up the rest of the bulb except a loose medullary portion about the ventricle.

Fibres destined for the superficial olfactory tracts, or *radices*, gather well out in the olfactory bulb into a bundle which lies in the

internal laminated layer of Deiter's cells dorsad of the ventricle (Plate II, Fig. 4, *rxl*.) These soon form a strong band which swings laterad and finally ventrad of the ventricle, as it passes caudad (Plate II, Figs. 5 and 6.) As the olfactory crus begins to fuse with the hemisphere, the superficial olfactory tract takes a position on the ventral surface of the latter, at the same time dividing into two fasciculi. A small median bundle, radix mesialis, (Plate II, Fig. 6, *rxm*; see also Plate I, Fig. 1) can be traced on the ventro-median surface of the hemisphere as far back as the cephalic end of the callosum. From both transverse and perpendicular longitudinal sections it appears as if its fibres pass dorso-caudad from this point into the septum lucidum, entering it from below between the cephalic terminus of the callosum and the anterior commissure. The fibres, however, have not in any case been actually traced through the whole of this course. Even if this be not the true course of these fibres, it seems hardly possible that the same relation could here prevail as in the opossum, where this radix passes directly through the brain cortex up to the gyrus fornicatus. The larger bundle radix lateralis, passes laterad and caudad toward the pyriform. As it passes into this lobe, it loses its compact form and spreads out over its ventral surface. It can be traced nearly to the caudal end of the pyriform. The inference is that these fibres dip into the pyriform along its whole ventral surface, especially toward the cephalic end, though this has not been actually observed.

Returning to the olfactory crus, a section taken through its middle portion shows the following structures (Plate II, Fig. 5.) The structure of the median half is the same as that of the olfactory bulb. The lateral surface is covered with the superficial olfactory tract *rxl* and remains of the glomerular layer. Entad of this tract is a cortical structure, *c*, like that of the hemisphere of which it is really a part. Still further entad, adjacent to the ventricle, are fasciculi of the præcommissural tract of the olfactory crus, *pc*. That this cortex is not only similar to but identical with that of the hemisphere is shown by sections taken at the point of union of the olfactory crus with the hemisphere (Plate II, Fig. 6,) where its continuity is demonstrated. At this point it makes up the body of the crus. Passing outward (cephalad,) it is gradually displaced by the various layers of the olfactory bulb, crowded to the dorsal surface, and finally in the bulb itself disappears entirely. The internal, or præcommissural olfactory tract lies within this mass of cortical cells, and I have not been able to trace its

fibres beyond them. It has been suggested by my brother, who first observed this relation in the opossum, that this is not necessarily a true olfactory tract, but may be the tract of this portion of the cortex.\* It passes caudad, sinking into the substance of the brain ventrad of the striatum, finally enters the base of that body, and continues its course, as a large well defined bundle, to the anterior commissure (Plate II, Figs. 2, 7, and 8, *pc.*)

*The Anterior Commissure* contains two sets of fibres. The cephalic and slightly larger bundle has been already described in connection with the olfactory tracts. The caudal branch arches backward, its fibres passing caudo-laterad along the ental border of the lower portion of the striatum. They can be followed as far back as the chiasm. In *Geomys* these two bundles fuse so that in the body of the commissure they cannot be distinguished. On the other hand in *Mus musculus* and *Fiber zibethicus* they remain distinct through the whole length of the commissure, and can be easily distinguished in transverse section when the brain is cut perpendicular longitudinally (*cf.* Plate II, Fig. 1.) The commissure, after the union of its two portions, curves gently dorsad, so that its highest point is in the meson. In *Erethizon* the same relation prevails as in *Geomys*, though somewhat obscured by the enveloping fibres of the striatum at the point of separation of the two bundles (Plate II, Fig. 3.)

*The Callosum* is as usual among rodents. It is, however, considerably larger in *Erethizon* than in *Geomys*, in the former case being thicker than the fornix commissure, in the latter scarcely as thick. It extends caudad to a point as far back as the superior commissure. In *Erethizon* its cephalo-caudad length is 14 mm, in *Geomys*, 6 mm.

*The Striatum* is a pear-shaped body with the more convex surface entad and the larger end cephalad. The dorsal aspect is arched and quite free from the surrounding organs. The ventral surface is not so sharply defined, but passes into the substance of the hemisphere. It is connected with the thalamus on the caudo-ventral aspect by the pyramidal tracts from the peduncle. The anterior commissure crosses

\*See a paper on the Brain of the Opossum, by C. L. Herrick, in the forthcoming number of the *Journal of Comparative Neurology*. According to this view, the various layers of the olfactory bulb, constituting the *pero* of Professor Wilder, are mechanically superposed upon the *pes*, or cortical and ventricular portion of the olfactory, without sustaining any vital relation to it.

I am also indebted to this paper for all comparative data with the opossum which occur in this article.



from the most ventral part. As Stieda says, the cephalic portion of the two striata are connected by the septum lucidum; but in these brains it is only the most ventral parts which are thus connected, since the anterior cornua of the lateral ventricles separate them dorsally and ventrad to these cornua the position of each is occupied by a loose reticulum of fibres lying chiefly in the direction of the ventricle.

The gray, or nonfibrous portions of the striatum contain numerous small cells, about half the size of the pyramidal cells of the cortex adjacent. Their forms vary, being chiefly pyramidal or fusiform, with the cell body almost perfectly transparent, but the nucleus and nucleolus stain very deeply. The nucleus, however, is not elongated, as in the pyramidal cells of the cortex, but circular, resembling both in size and shape the Dieter's cells which are very numerous in the striatum.

*The Fornix* is very large in these types, as in all rodents, and appears to take the usual course. Fibres of the descending fornix tracts are gathered into two firm bundles dorsad of the anterior commissure and pass out caudo-ventrad from the ventro-lateral angles of the fornix body. They pass rapidly caudad to the end of the cinereum, then dip abruptly downward into the mammillary. The latter body is unpaired externally. Internally its two cell-clusters, or niduli, are rather ill-defined and fuse in the meson ventrally. The descending fornix tracts passing ventrad envelop the niduli of the mammillare on their ectal and ventral aspects, at the same time sending fibres into their substance. The fibres of the ascending fornix tracts gather on the mesal and cephalic aspects of these niduli into close bundles which pass cephalo-dorsad and at the same time laterad in such a way as to form the usual figure-of-8 curve. This arrangement prevails in the opossum and conforms in the main with the description given by Meynert for the human brain.\* By reason, however of the great size of the ciner-

\*Stricker's Histology, American edition, 1872, p. 689. "The corpus candicans (s. mammillare) is a ganglion, which lies in a loop made by the anterior pillar of the fornix in twisting back upon itself (to enter the thalamus,) and by its means a certain number of the fibres of the fornix are made to pass directly into the tegmentum cruris cerebri. It is a mistake to suppose, with Jung, that fibres from the fornix simply traverse the substance of the corpus candicans, and that the superficial nerve-fibres which enclose the latter are to be referred to a different source. On the contrary, the descending branch of the crus fornix first invests the outer and posterior surface of the ganglion, and then twisting on itself, invests, under the form of the ascending branch of the same crus, the inner and anterior surfaces."

eum in rodents, the mammillare is pushed far caudad and, in fact, lies ventrad of the commissure of the optic lobes. Thus the ascending fornix tract, passes up in the most caudal part of the thalamus, instead of the cephalic part, as figured by Meynert. Plate II, Fig. 2, illustrates this ascending tract, lying between the caudal end of the third ventricle and the descending fornix tract, *f*.

*Optic Tracts.* Enveloping the dorsal and caudal aspects of the chiasm is a dense cluster of very large multipolar cells, which in the opossum has been called the anterior nidulus of the cinereum. They are enveloped in a very loose reticulum of fibres which is quite free from cells of other sorts. This causes their strong protoplasmic processes to stand out with especial distinctness. The optic tract passes laterad from the chiasm to the edge of the thalamus, thence dorsad as a compact bundle on its lateral aspect. It passes obliquely dorso-caudad over the prægeniculatum, then over the dorsal surface of the postgeniculatum, sending small fasciculi of fibres through both of these bodies back to the optic lobes. The rest of the fibres pass over the dorsal surface of the thalamus, entering the optic lobe on their cephalic aspect.

*The Medicommissure*, or soft commissure, fills nearly the whole of the dorsal portion of the third ventricle. As is often stated, it is merely an adhesion of the sides of the thalami in the median line; yet so intimate is the contact that considerable force is necessary to separate them in *Geomys*, and in *Erethizon* this could hardly be effected at all. Sections, moreover, reveal no internal break in the continuity of the substance of the thalami at this place, the meson being occupied by cells and fibres like the adjacent parts. In dissecting overhardened brains of the rat, however, the medicommissure some times falls apart of its own accord. It is nearly circular in section, in *Erethizon* about 6.5 mm. in diameter, in *Geomys*, 3 mm.

*Habene.* Each habena is a club-shaped body lying on the cephalo-dorsal aspect of the thalamus. Their larger ends are directed caudad and terminate near the median line immediately under the cephalic crus of the epiphysis and the superior commissure. The smaller ends gradually diverge as they pass into the tænia thalami and down over the cephalic face of the thalamus. Microscopically the habena consists of two sharply differentiated parts. The median portion is very densely packed with small cells which stain intensely. This is the nidulus of the habena. The lateral and cephalic portions

are occupied chiefly with fibres, especially ectad. There are also scattered cells lying laterad and ventrad of the nidulus of the habena, which stain very feebly. These are multipolar or bipolar, with occasional flask-cells like those of the rest of the thalamus. Meynert's bundle enters this nidulus from behind. This seems to be what has been described in Vol. V of this bulletin, page 76, as the nidulus of Meynert's bundle, though differing considerably in form and position from the arrangement there presented. This nidulus of Meynert's bundle has also been described in reptiles, though there much further caudad and ventrad.\*

The fibres of Meynert's bundle pass caudad beneath the tænia receiving some fibres from the latter, as far as the superior commissure. At this point they turn abruptly, pass caudo-ventrad through the thalamus, cross the fibres of the third nerve near their exit, and disappear. The tænia thalami pass cephalo-ventrad from the crus of the epiphysis, lying dorsad of the median, denser cell-cluster, or nidulus of the habena. They take the usual course, passing ventrad and laterad and at least at first somewhat caudad behind the anterior commissure, soon to be lost among the peduncular fibres.

*The Commissural Apparatus of the Habenæ and Optic Lobes.* In this region there are two commissural systems, the first cephalad, the second caudad of the epiphysis. The first system comprises the superior commissure and the commissure of the habenæ. These commissures are distinct in the lizard,† but in these types are fused. The whole may here be called the superior commissure. It is horseshoe shaped, the convexity being caudad and dorsad. Plate II, Figs. 9 to 12, illustrates these commissural systems in *Geomys*. Fig. 10 shows fibres from the lateral parts of the habenæ arching caudo-dorsad toward the meson, which, however, they do not quite reach at this level. Fig. 11

\*C. L. Herrick, "Topography and Histology of the Brain of Certain Reptiles," *Journal of Comparative Neurology*, Vol. I, p. 26.

†If the superior projecting portion of the habena surrounding the base of the stalk of the epiphysis be considered the habena proper, the deeper and more ventro-caudad portion may be distinguished as the nidulus of Meynert's bundle, or nidulus Meynerti. The fibres of Meynert can be traced to the portion mentioned (which in the black snake forms a distinct nidulus.) The cells are rather larger than those of the habena, and less compactly clustered about the walls of the third ventricle extending some distance ventrad."

†C. L. Herrick, loc. cit.

illustrates this commissure in its middle course slightly dorsad to Fig. 10. The cephalic crus of the epiphysis passes up from the highest point of this commissure. In *Erethizon* this commissure seems to be stronger and lies well up in the stalk of the epiphysis, the fibres arching much higher than in *Geomys*.

The second commissural system caudad of the ventricle of the epiphysis, is represented by the posterior commissure in the caudal crus of the epiphysis and the commissure of the optic lobes Sylvian commissure in the substance of the corpora quadrigemina dorsad of the aqueduct of Sylvius. The posterior commissure is a very strong band forming the roof of the third ventricle below the epiphysis, and also arching up into the caudal crus of that body. Its fibres pass ventrad and caudad into the substance of the optic lobes. The commissure of the optic lobes consists for the most part of sparse fibres passing latero-caudad into the dorsal portions of the optic lobes. At its cephalic end, fibres dip directly ventrad, arching slightly caudad, then cephalad in the substance of the tegmentum to a point cephalad of the peduncular nidulus. It is not a strong commissure and its fibres do not lie in immediate contact with the epithelium of the ventricle, as do those of the posterior commissure. Cephalad, the commissure of the optic lobes, seems to be almost, if not quite, continuous with the posterior commissure, being distinguished from it by its fewer fibres, its position removed from the ventricle, and the direction of its fibres. In the opossum, however, the continuity is distinctly broken dorsad of the cephalic end of the aqueduct. Figs. 9 and 14 of Plate II illustrate the posterior commissure; Fig. 10, the cephalic fibres of the commissure of the optic lobes; Fig. 11, the sparse fibres of this commissure in the middle portion of its course; Fig. 12, its caudal end, the fibres connecting the caudal members of the corpora quadrigemina. It is stronger and more compact here than any where else in its course.

*Cranial Nerves.* The internal course of the nerve roots, so far as observed, conforms in general to the usual descriptions. The course of the third is beautifully shown by transverse sections of *Geomys* (Plate III, Fig. 5.) Its nidulus lies immediately dorsad of the dorso-median fasciculus, the fibres of which pass through its lower portion. It is very small and sharply defined. The fibres passing down arch laterad and pass through the median portion of the large peduncular nidulus. The cells of the latter are very large and multipolar, being





much more angular and irregular than the equally large cells of the third nidulus. The nidulus of the fourth also lies immediately dorsad of the dorso median fasciculus under the aqueduct, but considerably caudad of the third. It is not in contact with the nidulus of the third, neither is it separated from it by fibres of the dorso-median fasciculus, as in *Arctomys* (Vol. V, Plate X, Fig. 1.) The fibres take the usual course to the value of Vieussens. The course of the fifth has not been traced in detail. The sixth nerve springs, as in *Arctomys* (Vol. V, Plate XVII, Fig. 2,) from a small nidulus in the loop formed by the genu of the seventh. Its fibres descend in several fascicles to a common exit. The seventh takes the usual course, passing first to the genu, which projects into the ventricle entad of the nidulus of the sixth, then turning abruptly ventrad in many strands to its nidulus in the ventral part of the medulla. The course of the eighth agrees pretty closely with *Arctomys*, as described by Prof. Tigh in Vol. V, pages 58 and 59. The nidulus of the root of the eighth nerve lies cephalad and dorsad of most of the fibres as they enter the medulla. The fibres of the most cephalic portion of the root pass through this nidulus and into the cerebellum. A little farther caudad fibres pass directly mesad under the caudal crus of the cerebellum as it enters the restiform body, some turning up into the cerebellum, some passing farther mesad toward the ventricle. Farther caudad these fibres pass through Deiter's nidulus, then mesad to the eminentia acustica. Deiter's nidulus lies immediately entad of the crus of the cerebellum at this point, with large deeply staining multipolar cells. Still farther caudad the great mass of the fibres of the eighth pass up and arch over the crus of the cerebellum directly into the eminentia acoustica, Deiter's nidulus having disappeared. The ninth and tenth roots are as hard to distinguish internally as externally. Their fibres pass dorso-mesad to a nidulus near the floor of the ventricle. The eleventh was not traced. The twelfth niduli lie immediately below the ventricle at the region of the calamus scriptorius. Their large multipolar cells lie in a clear stroma, and the two niduli are confluent in the meson. The fibres descend in many bundles to their exits, passing by the olives on the cephalo-lateral aspects of the latter.

## EXPLANATION OF PLATES.

### PLATE I.

Figures 8, 9, and 10 of this plate were drawn by C. L. Herrick.

*Fig. 1.* Brain of *Erethizon dorsatus*, ventral view, with the hypophysis, without the medulla and cerebellum, twice natural size.

*Fig. 2.* Region of the calamus scriptorius of *Erethizon dorsatus*, cerebellum removed, twice natural size; *r*, recessus lateralis; *p*, pedunculus cerebelli in section; *t*, fasciculus teres; *a*, eminentia acustica; *g vii*, genu of the seventh nerve; *o*, obex; *cl*, clava; *c*, calamus scriptorius; *gr*, fornicleus gracilis; *cu*, fornicleus cuneatus; *lc*, lateral columns.

*Fig. 3.* Brain of the *Erethizon dorsatus*, hemisected, median view, cerebellum removed, natural size; *c*, callosum; *f*, fornix commissure; *pc*, præcommissure; *mc*, medcommissure; *h*, habena; *p*, pedunculus cerebelli in section; *r*, recessus lateralis.

*Fig. 4.* Brain of *Erethizon dorsatus*, dorsal view, natural size.

*Fig. 5.* Brain of *Geomys bursarius*, ventral view, hypophysis removed, twice natural size; the Roman numerals refer to cranial nerve roots.

*Fig. 6.* Brain of *Erethizon dorsatus*, ventral view, hypophysis removed, twice natural size. The exit of the third nerve is abnormally on the lateral aspect of the crus in this brain, by reason of the fact that after leaving the brain it turns laterad some distance before penetrating the membrane; cf, *Fig. 1*.

*Fig. 7.* Brain of *Erethizon dorsatus*, lateral view, natural size.

*Fig. 8.* Brain of the white rat, dorsal view, natural size.

*Fig. 9.* Brain of *Geomys bursarius*, dorsal view, natural size.

*Fig. 10.* Brain of *Geomys bursarius*, lateral view, natural size.

### PLATE II.

The outlines of all figures of this plate were drawn with the aid of the camera lucida.

*Fig. 1.* Horizontal longitudinal section of the brain of *Mus musculus* at the level of the anterior commissure.

*Fig. 2.* Horizontal longitudinal section through the brain of *Geomys bursarius* at a level slightly ventrad of the anterior commissure; *rl*, radix lateralis, or lateral olfactory root; *pc*, præcommissural tract of the olfactory; *op*, optic tract; *f*, descending fornix tract entering the mammillary.

*Fig. 3.* Horizontal longitudinal section through the brain of *Erethizon dorsatus* at the level of the anterior commissure, drawn to the same scale as *Fig. 13*:

*f*, descending fornix tract shortly after leaving the fornix body; *op*, optic tract; *M*, Meynert's bundle; *III*, peduncular nidulus of the third nerve.

*Figs. 4, 5, 6, 7, 8.* A series of transverse sections through the brain of *Geomys bursarius*, drawn to a uniform scale, which is found under Fig. 5.

*Fig. 4.* Transverse section through the olfactory lobe; *rxl*, fibres of the radix lateralis (really the combined superficial olfactory tracts, *gr*, laminated granular layer; *g*, ganglionic layer; *n*, neuroglia, or gelatinus layer.

*Fig. 5.* Transverse section through the olfactory crus; *c*, cortex of the olfactory crus; *pc*, praecommissural tract of the olfactory; *rxl*, radix lateralis.

*Fig. 6.* Transverse section at the point of union of the olfactory crus with the hemisphere; *rxl*, radix lateralis; *pc*, praecommissural tract; *rxm*, radix mesalis, or medial olfactory root.

*Fig. 7.* Transverse section through the hemisphere cephalad of the callosum; *rxl*, radix lateralis; *pc*, praecommissural tract; *rxm*, radix mesalis.

*Fig. 8.* Transverse section just cephalad of the anterior commissure; *rxl*, radix lateralis; *pc*, praecommissural tract; *f*, fornix body; *c*, callosum.

*Figs. 9, 10, 11, 12.* A series of horizontal longitudinal sections through the brain of *Geomys bursarius*, illustrating the commissural apparatus of the habenæ and optic lobes, all drawn to the same scale as Fig. 2.

*Fig. 9.* Horizontal section through the thalamus and corpa quadrigemina at the level of the posterior commissure, which lies in the centre of the figure; *t*, tænia thalami beginning to descend from the habenæ; *op*, optic tract.

*Fig. 10.* Horizontal section through the entire brain immediately dorsad of Fig. 9; fibres of the superior commissure arch caudo-dorsad from the habenæ toward the meson; at the cephalic terminus of the corpora quadrigemina are fibres of the commissure of the optic lobes, just cephalad of which is a small triangular depression which marks the boundary between the optic lobes and the thalamus.

*Fig. 11.* Horizontal section through the thalami and corpa quadrigemina immediately dorsad of Fig. 10; *sc*, supracommissure; *op*, optic tracts; a few scattered fibres of the commissure of the optic lobes appear in the center of the figure.

*Fig. 12.* Horizontal section through the corpora quadrigemina taken near their dorsal limit; the dorso-median fissure has separated the cephalic members; the caudal members are connected by a strong bundle of fibres of the commissure of the optic lobes.

*Fig. 13.* Horizontal longitudinal section through the brain of *Erethizon dorsatus* dorsad of the last, slightly inclined ventro-cephalad; *th*, tænia thalami; *op*, optic tracts.

*Fig. 14.* Transverse section through the brain of *Erethizon dorsatus* at the region of the posterior commissure, which lies immediately above the third ventricle; *M*, Meynert's bundle; *p*, pyramidal tracts.

*Fig. 15.* Perpendicular longitudinal section through the brain of *Erethizon dorsatus* taken slightly laterad of the meson; *sc*, supracommissure; *M*, Meynert's bundle; *III*, exit of the third nerve with the peduncular nidulus.

## PLATE III.

A series of six transverse sections through the brain of *Geomys bursarius*, drawn to a uniform scale with the aid of the camera lucida, illustrating the hippocampus and tracts of the mesencephalon. The letters have the same value in all figures; *a*, primary fold of the hippocampus; *ch*, anterior part of chiasm; *cop*, commissure of the optic lobes; *f*, descending fornix tract; *gu*, gyrus uncinatus; *ipn*, interpeduncular nidulus; *le*, lamina ectalis (superior); *h*, lamina entalis (inferior); *M*, Meynert's bundle; *n III*, nidulus of the third nerve; *op*, optic tract; *pn*, peduncular nidulus; *rl*, radix lateralis olfactoria; *sc*, superior commissure; *III*, exit of third nerve.

*Fig. 1.* Transverse section immediately cephalad of the chiasm.

*Fig. 2.* Transverse section at the level of the superior commissure.

*Fig. 3.* Transverse section through the caudal end of the third ventricle.

*Fig. 4.* Transverse section at the region of the mammillary.

*Fig. 5.* Transverse section at the level of the third nerve.

*Fig. 6.* Transverse section slightly caudad of the last.

## METEOROLOGICAL OBSERVATIONS AT GRANVILLE.

---

The results gathered together in the following pages form a summary of the observations of local observers working under the direction of the Ohio Meteorological Bureau, from whose publications they are taken. It was thought that it would be of value to have all possible information concerning this one locality brought together so that comparisons can be easily made when the data have been accumulated sufficiently to make them useful. It was hoped that we might find the record of certain observations made privately—according to local traditions—a good many years ago, but these have not yet been brought to light. The work connected with the State Bureau was begun when the latter was founded in October, 1882. The late C. W. Bryant started the Granville station, but in January, 1883, Prof. J. L. Gilpatrick began to take observations and continued them until June, 1886, when M. P. Ashbrook succeeded him. His removal from the State soon after caused a break in the observations from Nov. 1, 1886 to Dec. 1888. At this time the Denison Scientific Association undertook to obtain an observer and secure the continuation of the interrupted work. W. H. Herrick then began to take the readings. Since then under its direction Mr. Sanford, E. U. Smith and A. H. Bartle have at different times had charge of the work. The desire to have their instruments in the best possible locality in this vicinity, the extreme top of College Hill, has made the taking of the readings quite laborious, and accounts for the difficulty experienced in securing perfect continuity in the observations, or long periods of service from the same observer.

## SUMMARY FOR NOVEMBER AND DECEMBER, 1882.

|                              | Nov  | Dec. |                                  | Nov  | Dec. |
|------------------------------|------|------|----------------------------------|------|------|
| Mean Relative Humidity.....  | 83.8 | 87.1 | Number of Clear Days.....        | 5    | 4    |
| Mean Temperature.....        | 38.0 | 27.3 | Number of Fair Days.....         | 13   | 14   |
| Highest Temperature.....     | 71.5 | 51.2 | Number of Cloudy Days.....       | 12   | 13   |
| Date.....                    | 11th | 21st | Number of Days Rain Fell.....    | 12   | 10   |
| Lowest Temperature.....      | 14.2 | 6.4  | Total Rainfall.....              | 1.33 | 2.03 |
| Date.....                    | 25th | 8th  | Average Daily Rainfall.....      | .044 | .065 |
| Range of Temperature.....    | 57.3 | 57.6 | Prevailing Direc'n of W'nds..... | SW   | SW   |
| Mean Daily Ran. of Temp..... | 14.7 | 15.5 |                                  |      |      |

## SUMMARY FOR THE YEAR 1884.

|                                     | Jan. | Feb. | Mar. | Apr. | May  | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|-------------------------------------|------|------|------|------|------|------|------|------|-------|------|------|------|
| Mean Relative Humidity.....         | 84.9 | 88.1 | 87.6 | 86.3 | 69.5 | 72.3 | 64.5 | 61.1 | 65.9  | 71.5 | 77.5 | 87.8 |
| Mean Temperature.....               | 18.7 | 34.1 | 36.6 | 47.9 | 61.1 | 71.7 | 72.2 | 73.2 | 70.4  | 56.9 | 37.8 | 29.4 |
| Highest Temperature.....            | 51.0 | 62.0 | 64.5 | 73.4 | 85.0 | 93.0 | 90.0 | 94.5 | 93.5  | 87.0 | 64.0 | 58.3 |
| Date of Highest Temperature.....    | 31st | 12th | 25th | 30th | 22d  | 23d  | 22d  | 20th | 8th   | 3d   | 40th | 30th |
| Lowest Temperature.....             | 16.3 | 3.0  | 0.9  | 21.6 | 34.7 | 51.0 | 52.0 | 45.0 | 40.0  | 24.0 | 12.0 | 19.5 |
| Date of Lowest Temperature.....     | 5th  | 29th | 4th  | 3d   | 29th | 15th | 8th  | 11th | 19th  | 24th | 24th | 19th |
| Range of Temperature.....           | 67.3 | 65.0 | 64.5 | 51.8 | 53.3 | 42.0 | 38.0 | 48.5 | 53.5  | 63.0 | 52.0 | 77.8 |
| Mean Daily Ran. of Temperature..... | 17.5 | 17.1 | 15.2 | 19.9 | 21.1 | 23.3 | 20.6 | 24.3 | 24.4  | 19.7 | 18.2 | 15.6 |
| Number of Clear Days.....           | 7    | 3    | 4    | 9    | 17   | 15   | 13   | 22   | 16    | 21   | 14   | 4    |
| Number of Fair Days.....            | 7    | 7    | 9    | 12   | 7    | 9    | 16   | 9    | 9     | 5    | 5    | 11   |
| Number of Cl'dy Days.....           | 17   | 19   | 18   | 6    | 7    | 6    | 2    | ---  | 5     | 5    | 11   | 16   |
| Number of Days Rain Fell.....       | 11   | 16   | 16   | 8    | 9    | 7    | 5    | 8    | 8     | 9    | 7    | 11   |
| Total Rainfall.....                 | ---  | 5.72 | 3.00 | 1.95 | 5.77 | 3.06 | 2.57 | .75  | 3.37  | 1.23 | 1.23 | 3.90 |
| Prevailing Direction of Wind.....   | SW   | W    | S    | W    | W    | S    | NW   | SW   | S     | W    | W    | W    |

## \*SUMMARY FOR THE YEAR 1883.

|                                  | Jan. | Feb. | Mar. | Apr. | May  | June | July | Aug  | Sept | Oct. | Nov  | Dec. |
|----------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Mean Relative Humidity----       | 84.0 | 84.6 | 82.9 | 75.9 | 76.0 | 74.0 | 70.0 | 64.7 | 66.4 | 79.0 | 79.1 | 88.9 |
| Mean Temperature -----           | 23.5 | 30.3 | 31.4 | 48.9 | 58.1 | 68.6 | 72.2 | 69.4 | 63.6 | 53.2 | 42.7 | 32.3 |
| Highest Temperature -----        | 54.0 | 70.9 | 65.0 | 86.0 | 84.7 | 86.0 | 91.0 | 92.5 | 89.0 | 80.8 | 70.0 | 56.0 |
| Date of Highest Temperature      | 27th | 16th | 18th | 14th | 9th  | 16th | 3d   | 22d  | 14th | 9th  | 9th  | 6th  |
| Lowest Temperature -----         | -1.5 | 6.0  | 5.0  | 21.9 | 32.7 | 43.0 | 43.0 | 40.0 | 36.7 | 31.0 | 9.0  | 7.0  |
| Date of Lowest Temperature       | 22d  | 1st  | 20th | 2d   | 22d  | 14th | 31st | 30th | 9th  | 21st | 16th | 22d  |
| Range of Temperature -----       | 55.5 | 64.9 | 60.0 | 64.1 | 52.0 | 43.0 | 48.0 | 52.5 | 52.3 | 49.8 | 61.0 | 49.0 |
| Mean Daily Range of Temp         | 16.3 | 15.2 | 18.8 | 20.8 | 22.0 | 21.1 | 21.8 | 23.6 | 23.6 | 16.3 | 17.2 | 15.5 |
| Number of Clear Days -----       | 2    | 6    | 9    | 9    | 11   | 11   | 23   | 18   | 10   | 8    | 10   | 9    |
| Number of Fair Days -----        | 12   | 9    | 12   | 11   | 13   | 15   | 7    | 11   | 13   | 8    | 12   | 7    |
| Number of Cl'dy Days -----       | 17   | 12   | 10   | 10   | 7    | 4    | 1    | 2    | 7    | 15   | 8    | 15   |
| Number of Days Rain Fell----     | 15   | 9    | 7    | 6    | 9    | 5    | 9    | 3    | 8    | 9    | 9    | 13   |
| Total Rainfall for the Month---- | 3.45 | 5.34 | 2.78 | 2.33 | 4.47 | 1.87 | 3.33 | .70  | 2.63 | 4.53 | 3.36 | 3.76 |
| Average daily Rainfall -----     | .111 | .191 | .090 | .078 | .144 | .062 | .107 | .023 | .088 | .146 | .112 | .121 |
| Prevailing Direction of Wind.    | W    | NW   | W    | WN   | SW   | SW   | W    | NW   | NW   | N    | S    | W    |

\*NOTE.—That the order of the Summaries for the years 1883 and 1884 are transposed.



## SUMMARY FOR THE YEAR 1885.

|                                  | Jan.  | Feb.         | Mar. | Apr. | May  | June        | July | Aug. | Sept.       | Oct. | Nov. | Dec. |
|----------------------------------|-------|--------------|------|------|------|-------------|------|------|-------------|------|------|------|
| Mean Relative Humidity----       | 84.1  | 82.5         | 81.0 | 86.7 | 79.0 | 73.6        | 68.2 | ---- | 73.9        | 76.2 | 82.6 | 84.6 |
| Mean Temperature-----            | 22.6  | 18.6         | 28.5 | 48.3 | 60.6 | 67.7        | 75.5 | ---- | 65.3        | 50.4 | 40.4 | 31.5 |
| Highest Temperature-----         | 56.0  | 50.0         | 58.0 | 82.0 | 85.0 | 90.0        | 93.0 | ---- | 83.5        | 76.0 | 67.0 | 59.0 |
| Date of Highest Temperature      | 6th   | 28th         | 31st | 23d  | 17th | 7th         | 17th | ---- | 26th        | 1st  | 7th  | 9th  |
| Lowest Temperature-----          | -10.0 | -12.         | -2   | 22   | 33.0 | 43.         | 46.  | ---- | 37.0        | 27.5 | 20.0 | -1   |
| Date of Lowest Temperature       | 22d   | 11th<br>20th | 20th | 14th | 2d   | 9th<br>30th | 1st  | ---- | 23d<br>24th | 31st | 29th | 7th  |
| Range of Temperature-----        | 66.0  | 62.0         | 6.0  | 6.3  | 52.0 | 47.0        | 47.0 | ---- | 46.5        | 48.5 | 47.  | 60.  |
| Mean Daily Range of Temp         | 16.1  | 20.1         | 17.0 | 20.3 | 21.1 | 23.8        | 23.2 | ---- | 22.1        | 19.0 | 13.7 | 14.9 |
| Number of Clear Days-----        | 13    | 11           | 9    | 10   | 9    | 17          | 24   | ---- | 18          | 12   | 11   | 5    |
| Number of Fair Days-----         | 5     | 7            | 10   | 13   | 16   | 10          | 7    | ---- | 2           | 8    | 5    | 7    |
| Number of Cl'dy Days-----        | 13    | 10           | 12   | 7    | 6    | 3           | 0    | ---- | 5           | 11   | 14   | 19   |
| Number of Days Rain Fell----     | 14    | 14           | 10   | 7    | 9    | 11          | 10   | ---- | 3           | 9    | 5    | 10   |
| Total Rainfall for the Month---- | 4.15  | 2.80         | .45  | 2.95 | 3.11 | 4.06        | 3.90 | ---- | 2.58        | 3.48 | 2.90 | 2.10 |
| Prevailing Direction of Wind.    | W     | SW           | W    | W    | W    | W           | W    | ---- | W           | W    | W    | W    |

## SUMMARY FOR THE YEAR 1886.

|                               | Jan. | Feb. | Mar. | Apr.  | May         | Jun.  | July  | Aug  | Sept | Oct.  | Nov   | Dec   |
|-------------------------------|------|------|------|-------|-------------|-------|-------|------|------|-------|-------|-------|
| Mean Relative Humidity----    | 91.7 | 88.1 | 88.5 | 85.5  | 75.0        | ----- | †     | 89.0 | 73.0 | ----- | ----- | ----- |
| Mean Temperature-----         | 23.5 | 26.8 | 38.4 | 48.9  | 63.7        | ----- | ----- | 69.8 | 65.0 | ----- | ----- | ----- |
| Highest Temperature-----      | 53.0 | 58.0 | 74.0 | 79.0  | 84.5        | ----- | 92.   | 89.0 | 90.5 | ----- | ----- | ----- |
| Date of Highest Temperature-- | 4th  | 11th | 19th | 15th  | 22d<br>30th | ----- | 29th  | 11th | 9th  | ----- | ----- | ----- |
| Lowest Temperature-----       | -11  | -10. | 8.   | 21.   | 37.5        | ----- | 50.3  | 44.0 | 37.0 | ----- | ----- | ----- |
| Date of Lowest Temperature--  | 11th | 5th  | 22d  | 8th   | 17th        | ----- | 21st  | 4th  | 21st | ----- | ----- | ----- |
| Range of Temperature-----     | 64.0 | 68.0 | 66.0 | 58.0  | 47.0        | ----- | 41.7  | 45.0 | 53.5 | ----- | ----- | ----- |
| Mean Daily Range of Temp      | 14.7 | 17.5 | 17.4 | 18.1  | 22.5        | ----- | 22.1  | 28.8 | 26.3 | ----- | ----- | ----- |
| Number of Clear Days-----     | 5    | 8    | 6    | 4     | 14          | ----- | 10    | 11   | 13   | ----- | ----- | ----- |
| Number of Fair Days-----      | 6    | 8    | 11   | 4     | 9           | ----- | 13    | 10   | 15   | ----- | ----- | ----- |
| Number of Cl'dy Days-----     | 20   | 12   | 14   | 5     | 8           | ----- | 3     | 10   | 2    | ----- | ----- | ----- |
| Number of Days Rain Fell----  | 14   | 4    | 12   | 7     | 12          | ----- | 6     | 8    | 9    | ----- | ----- | ----- |
| Total Rainfall for Month----- | 5.72 | .73  | 2.63 | ----- | 3.76        | ----- | 1.59  | 3.81 | 5.31 | ----- | ----- | ----- |
| Prevailing Direction of Wind  | W    | SW   | SW   | W     | S           | ----- | NW    | SW   | NW   | ----- | ----- | ----- |

\*The figures for April are from observations taken on the first seventeen days, except the 2d and 3d.

†Figures for July are from observations taken on all but first five days of month.

## \*SUMMARY FOR THE YEAR 1889.

|                          | Jan.  | Feb.        | Mar.        | Apr.  | May.  | June  | July. | Aug.  | Sept.     | Oct.  | Nov.  |
|--------------------------|-------|-------------|-------------|-------|-------|-------|-------|-------|-----------|-------|-------|
| Mean Barometer           | 30.06 | 30.18       | 29.99       | 30.02 | 29.96 | 30.01 | 29.97 | 30.09 | 30.04     | 30.11 | 30.09 |
| Highest Barometer        | 30.53 | 30.81       | 30.44       | 30.54 | 30.26 | 30.40 | 30.26 | 30.25 | 30.37     | 30.39 | 30.65 |
| Date                     | 19th  | 23d         | 30th        | 7th   | 5th   | 24th  | 6th   | 27th  | 27th      | 23d   | 16th  |
| Lowest Barometer         | 29.23 | 29.49       | 29.61       | 29.54 | 29.62 | 29.72 | 29.67 | 29.73 | 29.54     | 29.73 | 29.49 |
| Date                     | 27th  | 4th         | 7th         | 28th  | 30th  | 18th  | 19th  | 14th  | 20th      | 25th  | 21st  |
| Range of Barometer       | 1.297 | 1.326       | .831        | .995  | .639  | .686  | .582  | .518  | .827      | .660  | 1.154 |
| Mean Relative Humidity   | 83.8  | 76.4        | 71.3        | 67.4  | 69.2  | 80.4  | 76.7  | 69.1  | 77.9      | 74.2  | 83.1  |
| Mean Temperature         | 32.3  | 24.8        | 40.5        | 50.0  | 59.3  | 65.9  | 72.3  | 69.3  | 62.3      | 47.5  | 39.8  |
| Highest Temperature      | 55.0  | 59.5        | 72.0        | 79.0  | 89.0  | 86.5  | 92.0  | 92.0  | 91.5      | 76.5  | 66.0  |
| Date                     | 17th  | 17th        | 17th        | 19th  | 10th  | 30th  | 9th   | 31st  | 1st       | 11th  | 1st   |
| Lowest Temperature       | 14.0  | -1.0        | 18.0        | 19.0  | 34.5  | 40.5  | 53.0  | 49.5  | 36.0      | 27.0  | 18.0  |
| Date                     | 22d   | 23d<br>24th | 9th<br>30th | 6th   | 1st   | 1st   | 16th  | 16th  | 1st<br>2d | 24th  | 29th  |
| Range of Temperature     | 41.0  | 60.5        | 54.0        | 60.0  | 54.5  | 46.0  | 39.0  | 42.5  | 55.5      | 49.5  | 48.0  |
| Mean Daily Range of Temp | 13.5  | 15.6        | 19.2        | 21.1  | 21.1  | 17.5  | 20.2  | 23.9  | 19.9      | 17.1  | 14.1  |
| Number of Clear Days     | 7     | 5           | 9           | 10    | 9     | 5     | 12    | 20    | 10        | 12    | 3     |
| Number of Fair Days      | 9     | 9           | 7           | 10    | 15    | 11    | 13    | 5     | 10        | 5     | 7     |
| Number of Cl'dy Days     | 15    | 14          | 15          | 10    | 17    | 14    | 6     | 6     | 10        | 14    | 20    |
| Number of Days Rain Fell | 11    | 9           | 8           | 7     | 12    | 13    | 7     | 4     | 6         | 6     | 13    |
| Total Rainfall for Month | 3.79  | 1.25        | 1.07        | 1.43  | 2.90  | 3.30  | 3.76  | 0.73  | 3.91      | 2.23  | 4.50  |
| Prevailing wind          | SW    | SW          | NW          | N     | SW    | SW    | NW    | NW    | SE        | NW    | W     |

\*No observations were made at Granville from October, '86, to December 1, '88. Then the Denison University Scientific Association obtained an observer to work under the Ohio Meteorological Bureau. Weather and wind observations were begun December 1, and the reading of the instruments December 11, 1888.

No observations were made in December, 1889.

## SUMMARY FOR THE YEAR 1890.

|                          | Jan.               | Feb.  | Mar.               | Apr.             | May.  | June               | July. | Aug.  | Sept.               | Nov.         | Dec.             |
|--------------------------|--------------------|-------|--------------------|------------------|-------|--------------------|-------|-------|---------------------|--------------|------------------|
| Mean Barometer           | <sup>e</sup> 30.18 | 30.09 | <sup>†</sup> 30.24 | <sup>‡</sup> --- | 29.92 | <sup>§</sup> 29.92 | ---   | 30.05 | <sup>  </sup> 30.01 | 30.05        | <sup>¶</sup> --- |
| Highest Barometer        | 30.68              | 30.49 | 30.49              | ---              | 30.26 | 30.29              | 30.25 | 30.29 | 30.34               | 30.30        | ---              |
| Date                     | 22d<br>28th        | 9th   | 8th                | ---              | 11th  | 8th                | 21st  | 23d   | 28th                | 11th         | ---              |
| Lowest Barometer         | 29.82              | 29.49 | 29.99              | ---              | 29.59 | 29.86              | 29.68 | 29.70 | 29.87               | 29.73        | ---              |
| Date                     | 26th               | 14th  | 11th               | ---              | 5th   | 22d                | 2d    | 26th  | 13th                | 17th         | ---              |
| Range of Barometer       | .86                | 1.003 | .50                | ---              | .665  | .43                | .571  | .583  | .468                | .57          | ---              |
| Mean Relative Humidity   | 85.2               | 85.9  | 90.4               | ---              | 80.5  | 71.9               | ---   | .764  | 82.2                | 73.7         | 88.23            |
| Mean Temperature         | 37.3               | 39.2  | 28.7               | ---              | 59.0  | 73.0               | ---   | 67.7  | 61.6                | 43.5         | 27.27            |
| Highest Temperature      | 66.0               | 65    | 60.0               | ---              | 86.   | 92.9               | 92.7  | 93.9  | 85.8                | 69.0         | 49.0             |
| Date                     | 13th               | 4th   | 11th               | ---              | 30th  | 30th               | 31st  | 3d    | 6th<br>7th          | 7th<br>11th  | ---              |
| Lowest Temperature       | 6                  | 14.9  | 6.0                | ---              | 32.2  | 49.0               | 47.9  | 44.4  | 37.0                | 23.0         | 7.0              |
| Date                     | 22d                | 9th   | 7th                | ---              | 2d    | 7th                | 21st  | 23d   | 28th                | 26th<br>27th | 9th              |
| Range of Temperature     | 60.0               | 50.1  | 54.0               | ---              | 53.8  | 43.9               | 44.8  | 49.5  | 48.8                | 46.0         | 42.0             |
| Mean Daily Range of Temp | 17.4               | 17.9  | 15.7               | ---              | 19.5  | 21.7               | 23.3  | 20.4  | 20.5                | 21.2         | 17.8             |
| Number of Clear Days     | 2                  | 5     | 3                  | ---              | 1     | 4                  | 20    | 11    | 9                   | 11           | 11               |
| Number of Fair Days      | 9                  | 5     | 3                  | ---              | 18    | 13                 | 7     | 13    | 13                  | 8            | 8                |
| Number of Cl'dy Days     | 15                 | 18    | 9                  | ---              | 12    | 3                  | 4     | 7     | 6                   | 9            | 1                |
| Number of Days Rain Fell | 12                 | 8     | 6                  | ---              | 10    | 5                  | 7     | 11    | 11                  | 3            | 3                |
| Total Rainfall for Month | .049               | 6.36  | 1.83               | ---              | 3.36  | 2.43               | 2.03  | 4.48  | 7.33                | 1.91         | 1.16             |
| Prevailing wind.         | S                  | W     | N                  | ---              | S     | S                  | SW    | N     | SW                  | SW           | W                |

\*Mean all but first 4 days. †Mean first 15 days. ‡No observations in April and October. §No observations June 12-21. ||Mean of 28 days. ¶Mean of first 20 days.

# Denison University,

GRANVILLE, OHIO.

---

Has a beautiful and healthful location ; a large and able faculty, Classical, Scientific, Latin and Greek Philosophical and English courses of study ; Preparatory and Collegiate departments ; a well organized Academy ; a number of Free Scholarships ; an excellent working Library ; Laboratories and Workshop, with steam lathes, and iron and wood-working machinery ; ample Chemical and Physical Apparatus ; special provision for advanced students ; facilities for original work in Science ; good buildings and pleasant grounds ; opportunities for self-help to students.

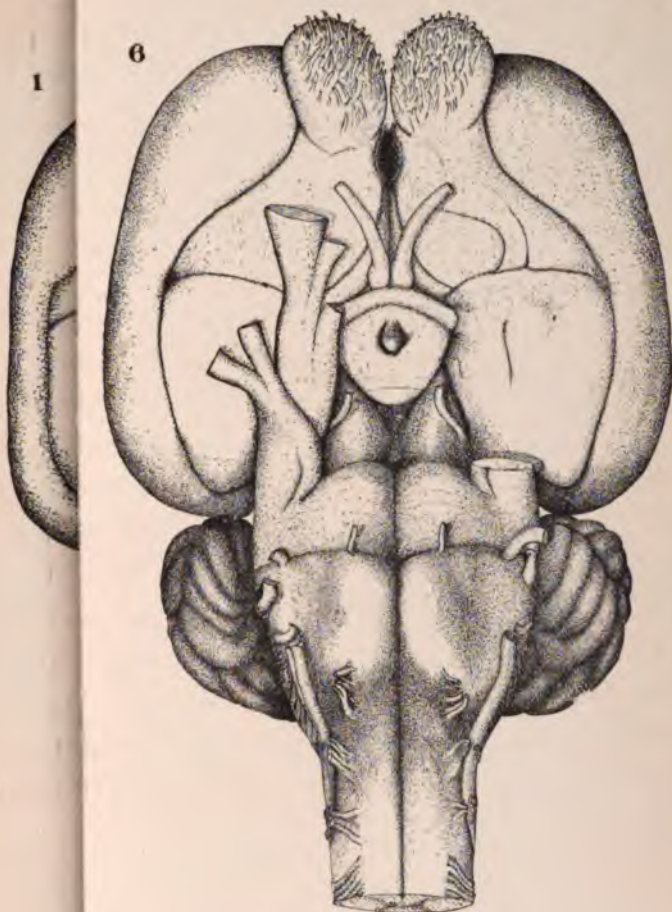
EXPENSES UNUSUALLY LOW.

Fall Term begins Thursday, September 17, 1891.

---

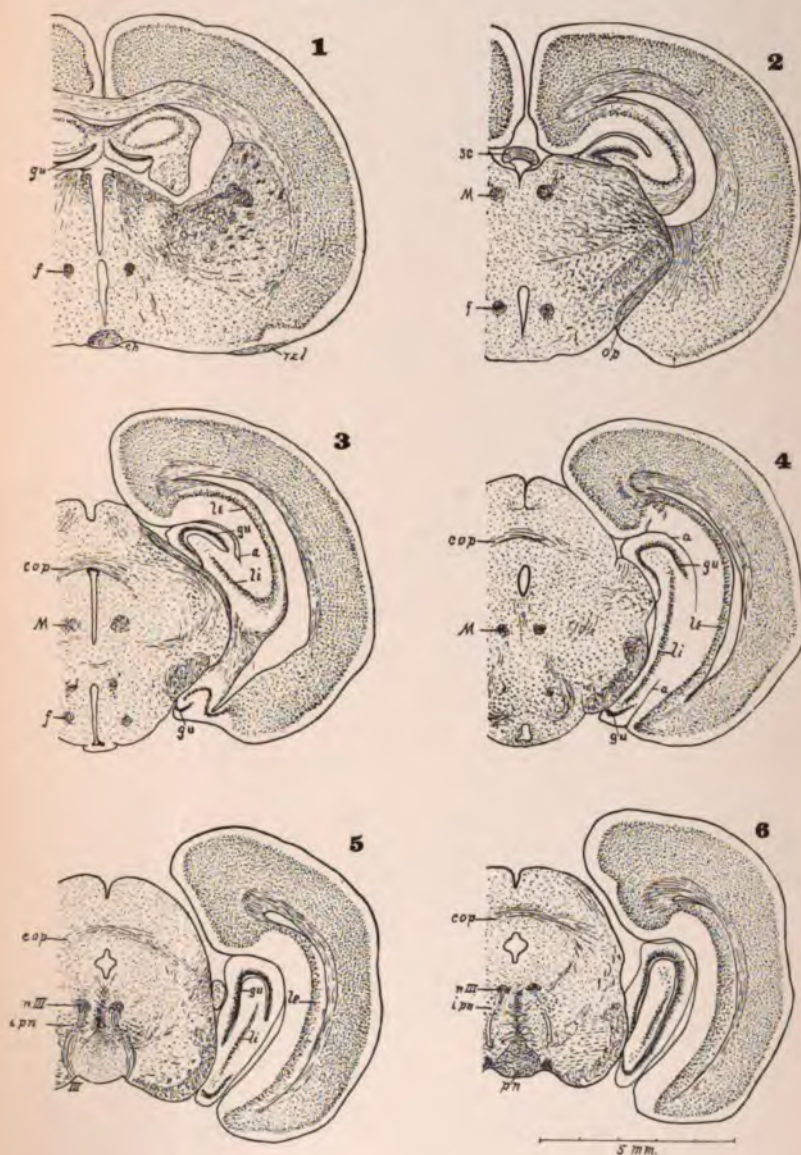
For Catalogue or further information address,

D. B. PURINTON, *President*,  
GRANVILLE, OHIO.











BULLETIN  
OF THE  
Scientific Laboratories  
OF  
DENISON UNIVERSITY.

---

*VOL. VI. PART II.*

WITH FIVE PLATES.

---

EDITED BY  
W. G. TIGHT, M. S.,  
DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

---

GRANVILLE, OHIO, JANUARY, 1892.



BULLETIN  
OF THE  
Scientific Laboratories  
OF  
DENISON UNIVERSITY.

---

*VOL. VI. PART II.*

WITH FIVE PLATES.

---

EDITED BY  
W. G. TIGHT, M. S.,  
DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

---

GRANVILLE, OHIO, JANUARY, 1892.



NOTES UPON THE CLADOCERA, COPEPODA, OSTRACODA AND ROTIFERA OF CINCINNATI, WITH DESCRIPTIONS OF NEW SPECIES.

BY C. H. TURNER.

[Plates I-II.]

This paper does not pretend to be a monograph of the Rotifera and Micro-crustacea of this locality. It is but the embodiment of the results of a three months' study of the Micro-crustacea and the Rotifera of Cincinnati, Ohio, and the neighboring country. It is not probable that all the species of this locality have been encountered. No doubt many interesting forms await the discriminating gaze of the patient investigator. Yet, it is hoped that the present paper will give a fair idea of the micro-carcinological and of the rotiferon fauna of this neighborhood.

In a paper of such modest pretensions, it is not deemed necessary to re-describe well known species. Nor is it thought wise to give the complete bibliography of each species. Therefore, the author has contented himself with appending to each known species only such facts as may prove of interest to other workers in this line; and to referring to one or two standard works, in which a complete description will be found.

In this connection, I gratefully express my indebtedness to Professor C. L. Herrick, who kindly placed at my service his extensive collection of papers upon this subject. Without such literary aid this paper would not have been attempted.

PART I, ROTIFERA.

The arrangement of this portion of this paper is the same as that followed by Messrs. Hudson and Gosse, in their monograph upon "The Rotifera, or Wheel-animalcules, Both British and Foreign." London: Longmans, Green & Co., 1889.



## ORDER I, RHIZOTA.

## FAMILY FLOSCULARIDAE.

## I GENUS FLOSCULARIA, Oken.

Sp. 1. *Floscularia ornata*, Ehrenberg.

*Floscularia ornata*, Hudson and Gosse. The Rotifera, or Wheel-animalcules,  
Vol. I, p. 50; pl. I, fig. 9.

*Floscularia ornata*, C. L. Herrick, Bull. of Sci. Lab. of Denison Univ.,  
Vol. I, p. 47.

This species is not very abundant in this locality. It is occasionally found attached to the roots of the duck weed (*Lemnaea polyrrhiza*, L.)

## ORDER II. BDELLOIDA.

## FAMILY PHILODINADAE.

## II GENUS PHILODINA, Ehrenberg.

Sp. 2. *Philodina roseola*, Ehrenberg.

*Philodina roseola*, Hudson and Gosse, The Rotifera, or Wheel-animalcules,  
Vol. I, p. 99; pl. IX, fig. 4.

This species is abundant in all of our pools that contain water plants. Occasionally it adopts unique habitations. I have often found one or more of them inhabiting the cast off shells of some cladocera.

Sp. 3. *Philodina megalotrocha*, Ehrenberg.

*Philodina megalotrocha*, \* \* \* Hudson & Gosse, The Rotifera,  
or Wheel-animalcules, Vol. I, p. 101; pl. IX, fig. 7.

This species appear to be quite rare. I have encountered it but once. Then it was found among a mass of filamentous algae which had been gathered from a shallow meadow pool. There it was quite abundant.

## III. GENUS ROTIFER, Schrank.

Sp. 4. *Rotifer vulgaris*, Shrank.

*Rotifer vulgaris*, \* \* \* Hudson and Gosse, The Rotifera, or  
Wheel-animalcules, Vol. I, p. 104; pl. X, fig. 2.

This species inhabits a few of our stagnant ponds. It is found in company with *Cyclops viridis*, Jurine, naiad worms and other filth-loving creatures.



## ORDER III. PLOIMA.

## SUB-ORDER. IL-LORICATA.

## FAMILY. ASPLANCHNADAE.

## IV. GENUS ASPLANCHNA, Gosse.

Sp. 5. *Asplanchna cincinnatiensis*, sp. n.

[Plate I; Fig. 4, 5.]

To the naked eye this beautifully transparent specimen resembles a miniature sea-urchin.

Body of female saccate, free from humps, widest caudad of the middle. The eye is single, cervical. When viewed by transmitted light, the eye appears to be dark brown or black. Trophi incudate, not enclosed in a mastax. Rami pointed, extremity unnotched, unserrated. About half way between the distal and the proximal extremity of each ramus a large tooth projects entad. In the adult female the trophi, when at rest, are usually lateral and situated in the cervical region. In the young they are usually median. Flocculent ribbon double, the laterad portion is convoluted at its two extremities; while the mesad portion is straight and bears about fifteen vibratile tags. Gastric glands oval. These animals often contain several embryos at the same time. The nearest ally to this species is *A. brightwellii*, Gosse; from this our specimen is readily distinguished by the pointed, unnotched rami.

Habitat: clear stagnant water, containing plant life. This species is not widely distributed but is very abundant where it does occur. Either this or a closely allied species has been encountered in clear stagnant pools that do not contain water plants. Length about 1 m.m.

The Brachionidae and allied forms appear to form the chief food of this species. I have seen individuals with the remains of two brachionids (*Brachionis urceolaris*, Ehrenberg), in its stomach at the same time. On another occasion I saw them gorged with the remains of *Anuraea cochlearis*, Gosse.

## SUB-ORDER. LORICATA.

## FAMILY. RATTULIDAE.

## V. GENUS MASTIGOCERCA, Gosse.

Sp. 6. *Mastigocerca rattus*, Ehrenberg.

*Mastigocerca rattus*, \* \* \* Hudson and Gosse, The Rotifera or Wheel-animalcules: Vol. II, p. 62: pl. XX, fig. 9.

*Monocerca rattus*, \* \* \* C. L. Herrick, Bull. Sci. Lab. of Denison Univ., Vol. I, p. 51.

This species is not widely distributed but is abundant among the roots of the duckweeds (*Lemnaceae polyrrhiza*, L.) of a few of our ponds and canal basins.

#### VI. GENUS RATTULUS, Ehrenberg.

Sp. 7. *Rattulus tigris*, Mueller.

*Rattulus tigris*, \* \* \* Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 65; pl. XX, fig. 13.

*Diurella tigris*, \* \* \* C. L. Herrick, Bull. Sci. Lab. Denison Univ., Vol. I, p. 49.

This species is very abundant in our weedy canal basins.

#### FAMILY DINOCHARIDAE.

#### VII. GENUS SCARIDIUM, Ehrenberg.

Sp. 8. *Scaridium longicaudum*, Ehrenberg.

*Scaridium longicaudum*, \* \* \* Hudson and Gosse, The Rotifera or Wheel-animalcules, Vol. II, p. 65; pl. XXI, fig. 13.

Although not widely distributed, this species is quite abundant among the roots of the duckweed (*Lemnaceae polyrrhiza*, L.) in the few ponds and canal basins where it does occur.

#### FAMILY SALPINADAE.

#### VIII. GENUS SALPINA, Ehrenberg.

Sp. 9. *Salpina mucronata*, Ehrenberg.

*Salpina mucronata*, \* \* \* Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 83; pl. XXII, fig. 1.

This species is found in all of our weedy pools.

Sp. 10. *Salpina brevispina*, Ehrenberg.

*Salpina brevispina*, \* \* \* Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 65; pl. XXII, fig. 4.

This is covered with impressed dots as described by Hudson and Gosse. This species is not so abundant as *S. mucronata*.

#### FAMILY EUCHLANIDAE.

#### IX. GENUS EUCHLANIS, Ehrenberg.

Sp. 11. *Euchlanis dilitata*, Ehrenberg.

*Euchlanis dilitata*, \* \* \* Hudson and Gosse, The Rotifera or Wheel-animalcules, Vol. II, p. 90; pl. XXIII, fig. 5.

*Euchlanis (dilatata) hipposideros*, \* \* \* C. L. Herrick, Bull. Sci. Lab. Denison Univ., Vol. I, p. 47; pl. III, fig. 2.

This is very abundant in those ponds that contain *Lemnacea polyrrhiza*, L.

Sp. 12. *Euchlanis triquetra*, Ehrenberg.

*Eucelanus triquetra*, \* \* \* Hudson and Gosse, The Rotifera or Wheel-animalcules, Vol. II, p. 91; pl. XXIII, fig. 4.

This species is not common.

#### FAMILY CATHYPNADAE.

##### X. GENUS CATHYPNA, Gosse.

Sp. 13. *Cathypna ohioensis*, Herrick.

*Distyla ohioensis*, \* \* \* C. L. Herrick, Bull. Sci. Lab. of Denison Univ., Vol. I, p. 54; pl. XII, fig. 1.

This species is not common. It has been encountered once or twice in our canal basins.

Sp. 14. *Cathypna leontina*, sp. n

[Plate I; Fig. 12.]

Lorica smooth, sub-ellipsoidal, cephalad margin excavated. Dorsal valve larger than the ventral. Caudad margin of the dorsal valve furnished with a projecting plate. Eyes ellipsoidal. Toes two, rod-like. Near the distal extremity of each toe, there is a small lateral tooth. From this tooth the toe slopes obliquely to a terminal point.

There is a deep lateral invagination and the animal has the habit of retaining its head within the lorica; these two traits render this species a *Cathypna* and not a *Distyla*. This species is separated from *Cathypna ohioensis*, Herrick, its nearest ally, by the smooth lorica and the structure of the toe.

This species is very rare. So far it has been encountered in but one small, weedy pool. Even there it is only occasionally seen.

##### XI. GENUS MONOSTYLA, Ehrenberg.

Sp. 15. *Monostyla lunaris*, Ehrenberg.

*Monostyla lunaris*, \* \* \* Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 98; pl. XXV, fig. 2.

This species is not common. Occasionally, it is found in our weedy pools.

Sp. 16. *Monostyla quadridentata*, Ebnenberg.

[Plate I; Fig. 10.]

*Monostyla quadridentata*, \* \* \* Hudson and Gosse, The Rotifera or Wheel animalcules, Vol. II, p. 100; pl. XXV, fig. 3.

*Monostyla quadridentata*, \* \* \* C. L. Herrick, Bull. Sci. Lab. Denison Univ., Vol. I, p. 53; pl. IV, fig. 3.

This species is abundant in all of our fresh water ponds.

Sp. 17. *Monostyla truncata*, sp. n.

[Plate I; Fig. 11.]

Lorica subovate, cephalad margin truncate, straight, caudad margin convex. Eye single, median, near the mastax. Mastax large, trophi sub-malleate. Foot moderate, non-contractile, terminating in a single toe.

In the specimen examined, the cephalad extremity of the body appeared to be bifurcate; this may have been an illusion due to the point of view.

This species is very rare. I have seen only one specimen. The truncated cephalad margin of the lorica serves to distinguish this species from all others.

## FAMILY COLURIDAE.

## XII. GENUS METOPIDIA, Ehrenberg.

Sp. 18. *Metopidea bractea*, Ehrenberg.

*Metopidea bractea*, \* \* \* Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 109,

*Squamella bractea*, \* \* \* C. L. Herrick, Bull. Sci. Lab. of Denison Univ., Vol. I, p. 54; pl. IV, fig. 2.

This species is not abundant.

Sp. 19. *Metopidia elliptica*, sp. n.

[Plate I; Fig. 8.]

Lorica smooth, sub-elliptical, about twice as long as broad. Caudad margin of ventral valve excavated. From the cephalad extremity of the body, two small, but conspicuous, lateral ears project. Joints of the foot sub-equal. The two terminal toes pointed, and as long as the remainder of the foot.

This species is not common. It is occasionally encountered in pools covered with monocellular algae.

Sp. 20. *Metopidia dentata*, sp. n.

[Plate I; Fig. 9.]

In the shape of the lorica, this species resembles *M. elliptica*.

Lorica smooth sub-elliptical, cephalad margin excavated. From the bottom of the cephalad excavation of the ventral portion of the lorica, a convex tongue projects half way to the cephalad extremity of the lorica. Caudad margin of the ventral valve excavated. The distal joint of the foot about as long as the combined length of the other two. The terminal toes are about as long as the distal joint of the foot. At the base each toe is supplied with a small, sharp, lateral spine.

Length of lorica about 104 micro-millimetres; breadth, about 65 micro-millimetres.

This species is very rare. Having seen it but once, I do not put much stress upon the convex tongue seen upon the cephalad portion of the ventral valve. I fear that that may be only a chance variation. But the relative lengths of the joints of the feet, the relative length of the toes, the spines at the base of the toes—all these are characters which distinguish it from *M. elliptica*, its nearest ally.

## FAMILY PTERODINADAE.

## XIII. GENUS PTERODINA, Ehrenberg.

Sp. 21. *Pterodina patina*, Ehrenberg.

*Pterodina patina*, \* \* \* Hudson and Gosse, The Rotifera or Wheel-animalcules, Vol. II, p. 112; pl. XXVI. fig. 11.

*Pterodina patina*, \* \* \* C. L. Herrick, Bull. Sci. Lab. of Denison Univ., Vol. I, p. 59; pl. I, fig. 3.

This species is very abundant around the roots of the duckweeds (*Lemnaceae polyrrhiza*, L.) of our larger ponds and canal basins.

## FAMILY BRACHIONIDAE.

## XIV. GENUS BRACHIONUS, Ehrenberg.

Sp. 22. *Brachionus pala*, Ehrenberg

*Brachionus pala*, \* \* \* Hudson and Gosse, The Rotifera, or Wheel-animalcules; Vol. II, p. 117; pl. XXVII. fig. 3; and pl. XXVIII, fig. 3.

This species is occasionally encountered in one or two of our shallow meadow pools. The specimens encountered so far resemble



what Ehrenberg has called *Brachionus ampliceros*. Hudson and Gosse consider this to be a variety of *B. pala*.

Sp. 23. *Brachionus urceolaris*, Ehrenberg.

*Brachionus urceolaris*, \* \* \* Hudson and Gosse, The Rotifera, or Wheel-animalcules, Vol. II, p. 118; pl. XXVII, fig. 6.

It is not easy to decide whether the species here described is *B. urceolaris* or *B. rubens*. After some hesitation I have considered it to be the former. I append a description:

Lorica sub-quadrangular, longer than broad. Cephalo-dorsad margin of the lorica bearing six straight teeth. Lateral teeth largest, Middle pair next in size. None of the teeth very large, the lateral teeth, however, are relatively larger than the corresponding teeth of the British species. Between the middle teeth there is a shallow, concave, depression. From the base of the tooth to the bottom of this depression is about as long as the height of the tooth. Cephalo-ventrad margin of the lorica slightly elevated and indented at the meson. Laterad margin of lorica straight, caudad margin convex. No caudal spines. A sub-square orifice in the middle of the caudo-ventrad margin of the lorica serves for the exit of the very flexible, wrinkled, foot. This orifice is bordered by two lateral papillae.

This species is often encountered in ponds containing plant life. Either this or a closely allied species is often found attached to the lorica of *Moina paradoxa*, Weismann.

Sp. 24. *Brachionus bakeri*, Ehrenberg.

[Plate I; Figs. 1-3.]

*Brachionus bakeri*, \* \* \* Hudson and Gosse, The Rotifera, or Wheel-animalcules; Vol. II, p. 120; pl. XXVII, fig. 8.

*Brachionus bakeri*, \* \* \* C. L. Herrick, Bull. Sci. Lab. of Denison Univ., Vol. I, p. 55.

This is the commonest of our Brachionidae and it is subject to great variations, not only in appearance but also in size. Some varieties appear to be fully one-third again as large as others.

The markings upon the lorica vary in different individuals. In some cases the lorica is smooth, while in others it is more or less faceted and granulated.

The shape of the depression between the middle teeth of the cephalo-dorsad margin of the lorica also varies. In some individuals this depression is acute, while in others it is strongly convex.



This species is found in ponds containing plant life. Sessile vorticellidae are often found attached to the lorica of this species. Sometimes they are situated at the cephalad extremity of the lorica, evidently appropriating a portion of the food attracted by the cilia of the *Brachionus*; while in other cases these vorticellidae are attached to other parts of the lorica.

Sp. 25. *Brachionus militaris*, Ehrenberg.

*Brachionus militaris*, \* \* \* Hudson and Gosse, The Rotifera or Wheel-animalcules; sup., p. 52; pl. XXXIV, fig. 23.

*Brachionus militaris*, \* \* \* C. L. Herrick, Bull. Sci. Lab. of Denison Univ., Vol. I, p. 56; pl. X, fig. 10.

During mid summer this species was abundant in all of our weedy pools. It seems to be fond of wallowing in the debris that is found at the bottom of such pools.

Sp. 25. *Brachionus tuberculus*, s.p. n.

[Plate I; Fig. 6.]

Lorica sub-rectangular, slightly wider than long (spines excluded), warted. The cephalo-dorsad margin is supplied with six teeth. The middle teeth are much larger than any of the others. Next in size come the lateral teeth. Between the two middle teeth there is a narrow, concave excavation. The cephalo-ventrad margin of the lorica is feebly convex. This margin is supplied with four small, sub-equal crenations. Two of these are situated, one near each lateral surface of the lorica; the remaining two are located near the meson. Between the two sub-median crenations there is a shallow concave excavation. The laterad margins of the lorica are convex. The caudad margin is straight. At its corners it is supplied with two long spines; these spines are more than half the length of the body of the lorica. The orifice for the protrusion of the foot is guarded by two small, unequal spines.

The whole lorica is densely covered with small tubercles, hence the name. These tubercles are found even upon the larger teeth of the cephalad margin and upon the spines. In a few individuals the spines appeared to be unwarted. The foot is very flexible.

During mid-summer this species was very abundant around the roots of the duckweeds (*Lemnaceae polyrrhiza*, L.), of one of our larger ponds.

## FAMILY ANURAEADAE.

## XV. GENUS ANURAEA, Gosse, nec Ehrenberg.

Sp. 27. *Anuraea tecta*, Gosse.

*Anuraea tecta*, \* \* \* Hudson and Gosse, The Rotifera or Wheel-animalcules, Vol. II, p. 123; pl. XXIX, fig. 10.

During the latter part of summer a single individual of this species was encountered in one of our shallow, weedy ponds.

Sp. 28. *Anuraea cochlearis*, Gosse.

[Plate I; Fig. 7.]

*Anuraea cochlearis*, \* \* \* Hudson and Gosse, the Rotifera or Wheel-animalcules; Vol. II, p. 124; pl. XXIX, fig. 7.

Myriads of this species have been encountered in one of our clear ponds. Here, as in England, they are much preyed upon by *Asplanchnas*.

## PART II. CRUSTACEA.

The arrangement adopted in this portion of this paper is the same as that followed by Professor C. L. Herrick, in his "Final Report Report upon the Crustacea of Minnesota."

## ORDER CLADOCERA.

## FAMILY SIDIDAE.

## I. GENUS SIDA, Straus.

Sp. 1. *Sida crystallina*, Mueller.

*Sida crystallina*, \* \* \* C. L. Herrick, Final Report on Minnesota Crustacea, p. 20.

This beautiful species appears to be quite rare in this locality. I have seen it but once. On the 17th of April, 1891, several were found among the *Sagittaria* in one of our canal basins.

## FAMILY DAPHNIDAE.

## II. GENUS MOINA, Baird.

Sp. 2. *Moina paradoxa*, Weismann.

*Moina paradoxa*, \* \* \* C. L. Herrick, Final Report on Minnesota Crustacea, p. 34; pl. A, figs: 1, 3, 6, 7, 9.

During the latter part of summer and the early part of fall, this species was very abundant in several of the stagnant pools that

occupy the bottom lands upon either side of the Ohio River. Ehippial females appear about the middle of September.

A certain species of *Brachionus*—probably *Brachionus urceolaris*, Weismann—is often found attached to this animal.

### III. GENUS SCAPHOLEBERIS.

#### Sp. 3. *Scapholeberis mucronata*, Mueller.

*Scapholeberis mucronata*. \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 42; pl. J, fig. 5.

This species is abundant in all of our ponds.

The brood cavity usually contains two embryos, each of which is about as long as that cavity. The head of one embryo is directed caudad, while the head of the other is directed cephalad.

Ehippial females appear about the latter part of September.

### IV. GENUS SIMOCEPHALUS.

#### Sp. 4. *Simocephalus vetulus*, Mueller.

*Simocephalus vetulus*, \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 46.

This species is abundant in all of our canal basins and in many of the ponds that contain plant life. It varies in hue from almost colorless to a brick red.

### V. GENUS DAPHNIA.

#### Sp. 5. *Daphnia pulex*, Mueller.

*Daphnia pulex*, \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 56.

This species is very abundant and is found in the same situations as *Moina paradoxa*, Weismann. They are fond of foul water and a dump pond is sure to be filled with them. The body is often covered with Vorticellidae and other Infusorians.

Ehippial females appear about the middle of September.

### FAMILY LYCEIDAE.

#### SUB-FAMILY LYCEINAE.

### VI. GENUS LYNCEUS.

#### *Sub-genus Alona*.

#### Sp. 6. *Alona porrecta*, Birge.

*Alona porrecta*, \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 99.



Although not abundant, this species has been encountered several times.

Sp. 7. *Alona glacialis*, Birge.

*Alona glacialis*, \* \* \* C. L. Herrick, Final Report on  
Crustacea, p. 100.

This species is very scarce.

Sp. 8. *Alona intermedia*, Sars.

*Alona intermedia*, \* \* \* C. L. Herrick, Final Report on  
Minn. Crustacea, p. 101; pl. I, fig. 15.

*Sub-genus Pleuroxus.*

Sp. 9. *Pleuroxus denticulatus*, Birge.

*Pleuroxus denticulatus*, \* \* \* C. L. Herrick, Final Report  
on Minn. Crustacea, p. 110; pl. G, figs. 12, 13.

This species is abundant in all of our canal basins and in several of the larger ponds.

The number of teeth upon the caudo-ventrad angle of the shell varies from one to three.

Sp. 10. *Pleuroxus hamatus*, Birge.

*Pleuroxus hamatus*, \* \* \* C. L. Herrick, Final Report on  
Minn. Crustacea, p. 110; pl. II, fig. 1.

Although not widely distributed, this species is quite abundant in the few canal basins and large ponds where it does occur.

A few slight deviations from the descriptions that I have seen of this species tempt me to give a complete description. I have not seen Professor Birge's description. Shell long and low, about twice as long as high. Length about 478 micro-millimetres, height about 278 micro-millimetres. Caudad margin of shell straight, about two-thirds as high as the greatest height of the shell. Caudo-ventrad angle of shell not toothed, but is margined with minute sharp points. Ventrad margin straight or feebly concave, supplied with a fringe of long hairs. Beak curved caudad, about twice as long as the antennules, including hairs. Shell is coarsely marked with the same lines that adorn the shell of *P. denticulatus*. In addition, the whole shell is closely striated with fine, undulating, sub-parallel, longitudinal, lines. These striations extend out upon the beak. Eye larger than the pigment fleck. First foot of the female supplied with a claw. The post-abdomen is long, slender, truncated.

Its caudad border is supplied with a row of sharp teeth. The distal teeth are the longest, thence they gradually decrease in length. The terminal claw of the post abdomen is supplied with two short basal spines.

#### VII. GENUS CHYDORUS, Leach.

Sp. 11. *Chydorus sphaericus*, Mueller.

*Chydorus sphaericus*, \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 116, pl. F, figs. 4, 7, 8, 10.

This species is very abundant in shallow, weedy, pools.

#### ORDER COPEPODA.

#### FAMILY CALANIDAE.

#### VIII. GENUS DIAPTOMUS, Westwood.

Sp. 12. *Diaptomus pallidus*, Herrick.

*Diaptomus pallidus*, \* \* \* C. L. Herrick Final Report on Minn. Crustacea, p. 142; pl. Q. fig. 17.

This species is quite abundant in two or three of our shallow ponds. Its transparency renders its detection difficult.

#### IX. GENUS CYCLOPS, Mueller.

(*Antennae 17-jointed.*)

Sp. 13. *Cyclops ater*, Herrick.

*Cyclops ater*, \* \* \* C. L. Herrick. Final Report on Minn. Crustacea, p. 145; pl. Q2, figs. 9-12.

*Cyclops ater*, \* \* \* C. L. Herrick, Crustacea of Alabama, p. 14.

This species is occasionally encountered in the larger canal basins.

Sp. 14. *Cyclops viridis*, Jurine.

*Cyclops viridis*, \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 145.

This species is found in all of our waters. It is especially abundant in stagnant water. Occasionally this animal is colorless, but usually it is rendered green by myriads of green infusoria which attach themselves to its body. Occasionally species of Vorticellidae are seen attached to its body.

Sp. 15. *Cyclops parvus*, Herrick.

*Cyclops parvus*, \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 145.

This species is frequently found in our canal basins.

Sp. 16. *Cyclops tenuicornis*, Claus.

*Cyclops signatus*, \* \* \* G. S. Brady, British Copepoda, Vol. I, p. 100; pl. XVII, figs. 4-12.

*Cyclops tenuicornis*, \* \* \* G. S. Brady, British Copepoda, Vol. I, p. 102; pl. XVIII, figs. 1-10.

*Cyclops tenuicornis*, \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 153. pl. R fig. 16.

This species is very abundant in many of our ponds and canal basins. Here we have two distinct varieties. In one variety the knife-edge upon the distal joint of the antennae is smooth, in the other it is toothed. This second variety might, with propriety, be divided into two sub-varieties. In one, the usual case, the teeth upon the knife-edge are small triangles; in the other they are stout hooks. The case where the teeth are small triangles corresponds to *C. signatus*, Koch.

(Antennae 12-jointed.)

Sp. 17. *Cyclops serrulatus*, Fischer.

*Cyclops serrulatus*, \* \* \* G. S. Brady, British Copepoda, Vol. I, p. 109; pl. XXII, figs. 1-14.

*Cyclops serrulatus*, \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 157; pl. O, figs. 17-19.

This species is common in all of our weedy ponds.

Sp. 18. *Cyclops fluviatilis*, Herrick.

*Cyclops fluviatilis*, \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 159; pl. Q5, figs. 1-9.

*Cyclops fluviatilis*, \* \* \* C. L. Herrick, Alabama Crustacea, p. 15.

Although not widely distributed, yet this form is very abundant in the few peaty pools where it does occur.

(Antennae 11-jointed.)

Sp. 19. *Cyclops phaleratus*, Koch.

*Cyclops phaleratus*, \* \* \* G. S. Brady, British Copepoda, Vol. I, p. 116; pl. XXIII, figs. 7-13.

*Cyclops phaleratus*, \* \* \* C. L. Herrick, Final Report on Minn. Crustacea, p. 161; pl. R, figs. 6-10.

This species is rare.

(Antennae 8-jointed.)

Sp. 20. *Cyclops fimbriatus*, Fischer.Cyclops crassicornis, \* \* \* G. S. Brady, British Copepoda,  
Vol. I, p. 118; pl. XXIII, figs. 1-6.Cyclops fimbriatus, \* \* \* C. L. Herrick, Final Report on  
Minn. Crustacea, p. 162, pl. R, fig. 11.

This species is abundant in all of our pools. It varies in color from a faint pinkish hue to a brick red.

## ORDER OSTRACODA.

## X. GENUS CYPRIS, Mueller.

Sp. 21. *Cypris virens*, Mueller.Cypris virens, \* \* \* G. S. Brady, Recent British Ostracoda,  
p. 364, pl. XXIII, figs. 23-32; pl. XXXVI, fig. 1.Cypris virens, \* \* \* Brady and Norman, Ostracoda of North  
Atlantic and Northwest Europe, part I, p. 74.Cypris virens, \* \* \* C. L. Herrick, Alabama Crustacea, p.  
24; pl. VI, fig. 3.

This species is abundant in our shallow, grassy ponds.

Sp. 22. *Cypris sp* (?)

[Plate II; Figs. 11-13.]

Although agreeing in many particulars with *C. virens*, Jurine, this species differs from it in the following respects:

1. The caudad half of each valve is marked with a series of concentric lines which in appearance resemble a nest of test tubes that has been bent into the shape of a retort.
2. The ventrad border of each valve is fringed with a row of tubercles. Each tubercle terminates in a hair. (Some specimens of *C. virens* are said to possess this feature.)
3. The caudad margin of the post abdomen is smooth.

During the summer this species was very abundant in several of our shallow, weedy pools. Among dozens examined no females were encountered. It will be noted that its habitat is the same as that of *C. virens*. It is possible that it is the male of that species.

Sp. 23. *Cypris herricki*, sp. n.

[Plate II; Figs. 1-10.]

In a lateral view, the shell is sub-triangular, highest near the middle. The ventral margin is straight, excepting at its cephalad



extremity, where, after a shallow concave notch, the margin is convex. The remainder of the margin is strongly convex. From the above described ventral notch, a well defined, feebly convex, line passes dorsad to the opposite margin. That portion of the shell which lies cephalad of this line is usually curved laterad. From within the cephalad and caudad extremities of the valves numerous hairs protrude.

In a dorsal view, the shell is sub-fusiform, being widest caudad of the middle. At their caudad extremity the valves are slightly divaricated, while at their cephalad extremity they are closely approximated. The shell is covered with fine reticulations and minute hairs. In addition to these, it is marked with conspicuous dark green bands. These bands are arranged as follows: One, parallel to and almost adjacent to the mesal border of the shell, extends from the caudo-ventrad angle of the shell dorso-cephalad almost to the cephalad extremity of the valve. There it divides. One portion continues in the same course to the cephalo-ventrad extremity of the valve. The other, turning laterad, passes ventrad for a short distance and terminates in a sharp point. At the origin of this line there is a large, convex blotch, which extends ventrad a short distance. Near the centre of the figure several bands fuse in such a manner as to form a hollow, sub-square figure. From the cephalo-dorsad corner of the square a tongue passes ventro-caudad into the square. The length of this tongue and the angles it makes with the sides of the square vary slightly in different individuals. Usually it extends almost to the centre. From this same angle of the shell a band projects ectad. After passing cephalad a short distance, this band forms a convex curve and passes caudo-dorsad almost to the margin of the shell. From the caudo-dorsad angle of the square a short band passes dorso-caudad and fuses with a broader band which passes caudad, approximately parallel to the dorsal margin of the shell. From this same corner another band passes caudo ventrad almost to the caudad margin of the shell. This band is approximately parallel to the band just described. From the caudo-ventrad angle of the square a band passes caudo-ventrad almost to the caudo-ventrad extremity of the shell. In the caudad portion of its course this band curves dorsad, otherwise it is approximately parallel to the band last described. From the cephalo-ventrad angle of the square, a short band projects ventrad and then broadening, forms a boot-shape band. The short heel of this boot projects caudad and

terminates in a point, the long toe extends cephalad and terminates bluntly. From the same corner of the square, a second band projects cephalad to about the level of the toe of the boot. There it fuses with a spike-shape band which extends cephalo-ventrad from near the cephalo-dorsad angle of the square to about the cephalo-ventrad extremity of the shell. The head of the spike is at the caudo-dorsad extremity of the band. The two bands fuse near the head.

The number of lucid spots is about eight. They are situated in the centre of the valve and ordinarily are enclosed within the square above described.

The sketches of the appendages are self-explanatory. However, I will call attention to two points:

1. The brush upon the second pair of antennae does not extend quite to the distal extremity of the terminal claws of the same.
2. At the base of the distal joint of the second foot we find two claws. The caudad claw is much the larger and is bordered with a row of small teeth.

Length of shell about 3 millimetres; height about 1 millimetres. Excepting *C. perlegans*, Herrick, this is believed to be the largest member of this genus yet discovered. Its large size renders it an excellent subject for class work.

So far this species has been encountered in but one locality. In the shallow weedy tongue of one of our canal basins it is quite abundant.

#### XI. GENUS CYPRIDOPSIS, Brady.

##### Sp. 24. *Cyprodopsis vidua*, Mueller.

*Cypridopsis vidua*, \* \* \* G. S. Brady, Recent British Ostracoda, p. 375. pl. XXIV, fig. 27-36, 46.

*Cypridopsis vidua*, \* \* \* Brady and Norman, Ostracoda of the North Atlantic and Northwestern Europe, part I, p. 89.

*Cypridopsis vidua*, \* \* \* C. L. Herrick, Alabama Crustacea, p. 31; pl. IV, fig. 1.

This species is common in all our pools. *Variety Obesa* is occasionally seen.

## EXPLANATION OF PLATES.

## PLATE I.

- Fig. 1. *Brachionus bakeri*. [Variety] Lorica, ventral view.  
 Fig. 2. do do Cephalo-dorsad margin of the lorica, one variety.  
 Fig. 3. *Brachionus bakeri*. Dorsal view.  
 Fig. 4. *Asplanchna cincinnatiensis*. The left focculent ribbon is not shown.  
 Fig. 6. *Brachionus tuberculus*. Lorica, ventral view.  
 Fig. 7. *Anuraea cochlearis*.  
 Fig. 8. *Metopidia elliptica*. Ventral view.  
 Fig. 9. *Metopidia dentata*. Lorica, with foot. Ventral view.  
 Fig. 10. *Monostyla quadridentata*.  
 Fig. 11. *Monostyla truncata*.  
 Fig. 12. *Cathypna leontina*. Ventral view. Lorica, with toes, trophi, and eye.

## PLATE II.

- Fig. 1. *Cypris Herricki*, sp. n., lateral view.  
 Fig. 2. do do dorsal view.  
 Fig. 3. do do one of the first pair of antennae.  
 Fig. 4. do do one of the second pair of antennae.  
 Fig. 5. do do mandible.  
 Fig. 6. do do first maxilla.  
 Fig. 7. do do second maxilla.  
 Fig. 8. do do first foot.  
 Fig. 9. do do second foot.  
 Fig. 10. do do post abdomen.  
 Fig. 11. *Cypris* sp. (?) lateral view.  
 Fig. 12. do mandible.  
 Fig. 13. do feet.



1.



2.



4.



6.



5.



8.



3.



7.



9.



10.



11.



12.







1.



12.



2.



7.



4.



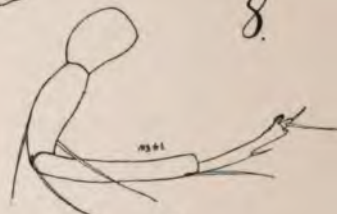
8.



13.



11.



9.



5.



3.



10.



6.





## THE CEREBRUM AND OLFATORIES OF THE OPOSSUM, DIDELPHYS VIRGINICA.

By C. L. HERRICK.

With Plates A. B. and C.

Material had been collected over a year ago for a study of the brain of the opossum, but, for various reasons, the completion of the paper was delayed until it now seems best to offer such notes as were collected upon the cerebrum in their necessarily incomplete form. This has seemed the more desirable in as much as this paper forms a portion of a series especially devoted to the histology of the gray matter and commissures of the cerebrum in the several groups of vertebrates and because it in a sense prepares the way for the delayed portion of the rodent paper begun in volume V of this bulletin.

### EXTERNAL FORM.

In most particulars the brain of the opossum resembles that of rodents, although the relative size of the cerebrum is less than in any rodent type. A larger part of quadrigemina is exposed and the proportions of the infra-rhinalis to the supra-rhinalis portion of the cerebrum is less. In one respect only does the opossum brain approach that of carnivora, i. e. in the possession of an apparent homologue of the crucial sulcus. But there is good reason to doubt the reliability of this homology.

*The olfactories* are relatively very large and are obliquely attached to the crura. They contain, as shown beyond, a considerable mass of cortex upon the pes. Longitudinal sections show a strong medio-ventral fossa filled by a thickening of the pero, especially the glomerular layer. The cavity or rhinocœl is very large and connected with the lateral ventricle by an oval curved aqueductus cruris. The crura are large and exhibit a distinct radix lateralis.

*The cerebrum* is pyriform with the caudal portions of the hemispheres divaricated. The hemispheres may each be divided both morphologically and histologically into a dorsal and ventral portion sepa-

rated laterad by the rhinalis fissure and mesad by the splenialis. The portion dorsad of these almost continuous fissures may be regarded as the dorsal lamina or mantle par excellence, while that part beneath contains the ventral lamina and alae. A large part of the ventral portion is devoid of cortex in the usual sense. The dorsal surface is divided into a small frontal lobe, which is circumscribed very deeply from the rest, and a large ovate parieto-occipital portion, which is not subdivided.

The ventral portion is likewise divided into an anterior post-rhinal lobe occupying the region in front of the chiasm and fusing with the crus cephalad, and the large pyriform lobe with its modified cortex. The latter is expanded by the ventral part of the hippocampus into which it passes caudo-ventrad.

The sylvian fissure is not pronounced and does not extend across the rhinalis fissure. A slight longitudinal depression extends longitudinally of the pyriform. This marks the course of the olfactory fibres and limits the non-cortical from the cortical portion. All of the region ventrad is devoid of a genuine cortex. Dorsad of it, the surface is occupied by olfactory fibres as far as to the rhinalis fissure. The mesad surface is separated by the splenialis or calloso-marginal fissure into a dorsal and ventral portion, but this fissure is relatively farther dorsad than the rhinalis by reason of the interpenetration of the thalamus. Cephalad, the rhinalis and splenialis unite and cut off the projecting frontal lobe from the crus beneath.

There is a slight fissure where one might look for the callosal, but in the absence of that commissure it is but the union of the cortex of the gyrus fornicatus with the base. All beneath this fissure is devoid of true cortex and is continued caudad into the septum and corpus fornicis. (See Figs. 3 and 4, Plate A.) The splenialis grows deeper as it passes caudad, following the arch of the hemisphere until it lies in a dorso-ventral line. By comparing the longitudinal sections of Plate B with the transverse series of Plate A, the course of the fissure and the structure of the hippocampus will be perfectly obvious. The commissures are discussed beyond.

The thalamus is about as in rodents.

#### MINUTE ANATOMY.

*Rhinencephalon.* The olfactory lobe, as a whole, is of relatively very large size, being expanded in all directions beyond the crus and especially produced cephalo-dorsad. No part of the dorsal part of the



pero or cap of the tuber is covered by the cerebrum. The lobe is much larger, for example, than the precrucial lobe of the hemisphere. As seen from above, the outline is ovoid with the larger end caudad and the longer axis passing obliquely caudo-ventrad. The ventral aspect is acutely ovate or subtriangular with the apex mesi-caudad. In its natural position, the infero-cephalic surface is curved and the greater portion is covered by the fibres of origin of the olfactory nerve.

*The pero* (as this term is used by Wilder) consists of a cap or buskin-like body which entirely clothes the lobe. Its substance extends nearly to the ventricle, which latter is, however, clothed with a larger or smaller mass of white matter with a gray envelope differing totally from that which pertains to the pero proper. Passing entad, we encounter successively the following layers. 1. The fibre layer, which consists of apparently irregularly disposed fibre clusters intercrossing confusedly. Among the fibres are numerous blood-vessels and the usual inoblasts and leucocytes accompany the fibres. 2. The glomerular layer is of the usual structure; fibres from the cells next to be described pass into the dense ball of neuroglia and emerged clothed with their myelin as distinctive olfactory fibres. It is suggested that the glomerule is simply a locus devoted to the manufacture of the myelin sheaths of the nerves. In this case the only active agents in the process must be the large number of wandering cells or Deiter's corpuscles which congregate about the glomerules in large numbers. If the Deiter's cells have this function here it would be easy to predicate a similar function of the same cells elsewhere. There are many reasons for such an assumption in other parts of the brain. The presence of exactly similar cells in the tracts of medullated fascicles elsewhere is suggestive. (See also Flechsig's works on the development of the sheaths.) The same explanation may be given for the exactly similar cells in the laminated granular layer. 3. The external neuroglia layer is in this case not distinct from the layer next entad, as the ganglionic layer is dispersed throughout them both. In this respect the opossum differs from any other mammal examined. The ganglion cells are perhaps most abundant near the external boundary of the laminated granular layer, but are irregularly distributed to the very base of the glomerular layer. The ganglion cells are of pyramidal form and large size with a (generally single) strong apex process which can be traced as a large non-medullated fibre to the glomerular layer. From the base several processes extend latero-entad or laterad

and after penetrating the layers of the granular zone their fibres continue toward the crus. It has not proven possible to determine whether the fibres anastomose and form a reticulum or whether there is one main branch and lateral nutrient roots as claimed in other cases. Our own impression is that there is considerable lateral anastomosis in the neuroglia layers and that fibres after passing into the granular layer soon again acquire medullary sheaths. If, as we believe, the ganglion cells are to be compared with the cells of the spinal ganglia, it would appear that this locus is a point where nourishment is received and hence the myelin sheaths must be interrupted. This space devoid of medullary sheaths is richly supplied with the Deiter's cells which convey the nourishment and also affords the opportunity for intercommunication. The ganglion cells are comparatively large and bear a close resemblance to those of fishes, for example. The nuclei seem to be normally ovoid; but the cells frequently shrink during preparation and this shrinkage especially affects the nucleus.

4. The granular layer is well developed and laminated, each lamina being separated by tracts accumulated from the ental processes of the ganglionic cells. The fibres near the tip seem to pass almost directly through this layer to accumulate at the ventricular surface where they have been considered as forming a part of the pes though actually belonging to the pero. Farther caudad the course of the fibres is oblique. Two different types of corpuscles may be distinguished in these granular laminæ, one being globular and rather larger than the ovoid and darker bodies which we have supposed might be those connected with the function of formation of sheaths for these fibres, while the former would retain the more purely nutritive function.

*The pes.* Cephalad the ventricular epithelium alone represents the core of the lobus olfactorius. The epithelium resembles that of other parts of the ventricular system. A few connective fibres extend into the granular layer and bear the usual dark inoblastic nuclei. Near the point where the lobe joins its crus the pes develops a different ental structure. Here there is an invasion of cortex from the cerebrum. These cells exhibit no orderly arrangement cephalad, but are irregularly disposed and are pyramidal and deeply staining. The area is triangular, being bounded caudad by the peculiar structure of the post-rhinal lobe, from which it is separated by a distinct fibre tract.



The greater part of this cortex pertains to the crus and may be there considered.

*Crus olfactorius.* The crus terminates in the pes obliquely, the lateral and dorsal portions being longest. Ventrally it is chiefly made up of the radices of tracts from the pero. There are three such fibre-bundles; the largest, or *radix pedis lateralis*, is an exceedingly strong band, as in rodents. Its development stands in direct proportion to that of the olfactory lobe and this, in turn, with that of the hippocampus. The fibres collect in the granular layer of the pero and then about the ventricle, accumulating chiefly mesad and ventrad. On entering the pes they encounter the invading cortex cruris and are driven ectad, thence laterad superficially to the cortex cruris, where they form a strong bundle passing caudad and somewhat laterad along the fissura radialis to the lobus pyriformis, thence for the most part to cross mesad and entad into the hippocampus, especially the fornicate gyrus. The tract of the fibres caudad is not compact but they spread out to some extent upon the pyriform. The fibres of this ectal olfactory tract are in part overlapped by fibres of a different character.

The *radix pedis mesalis*, on the other hand, is very small and disperse. Its fibres, which arise on the ventral and mesal, as well as especially in the meso-dorsal part of the crus, pass in the neuroglia layer and remain ectad to the cell zone until reaching the neighborhood of the splenialis fissure, where they cross to the gyrus fornicatus. The bundles do not unite to form a single tract but remain largely isolated from each other.

There is no external indication of a *radix pedis intermedius*, but we encounter a few bundles which apparently arise from the ventral part of the crus and passing caudad through the substance of the lobus post-rhinalis emerge mesad and ectad to unite with the bundles of the *radix mesalis* on their way to the gyrus fornicatus. The fibres enter the peduncular tracts in their dorsad course and pass through them. As indicated above, the dorsal, lateral and mesal aspects of the crus are covered by cortical masses.

Thus far we have been dealing with tracts which undoubtedly pertain to the olfactory pero or ganglion proper. Greater difficulty arises in construing the so called ental olfactory tract (*radix mesalis* of fishes.) Following suggestions arising from these studies, Mr. C. Judson Herrick has investigated the relations of the cortex cruris to the pero, in rodents. He arrives at the conclusion (Bul. Denison

Univ., Vol. VI,) that there is no direct connection between the tractus præcommissuralis cruris, or internal olfactory tract, and the olfactory substance. On the other hand, the fibres of the tract seem to be largely derived from the cortex cruris and its forward extension into the pes. Of this relation we have been long convinced in the opossum, as well as lower vertebrates, though it would be premature to decide that there is no secondary connection with the pero. A few general considerations might be advanced to indicate the bearing of the conclusion suggested.

1. The olfactory, as a sensory nerve, should be derived from the dorsal part of the primitive medullary tube or embryonic vesicle. According to the above suggestions, such an origin is the only one. The three superficial radices ultimately reach the gyrus fornicatus. Now, if the callosum be considered the partial homologue of the dorsal commissure of the cord, of which there can be little doubt, the cephalic part of the hippocampus, i. e. gyrus fornicatus, is the homologue of the most dorsi-mesal part of the vesicle. The commissura fornicis is also a portion of the dorsal commissural system and the connected parts of the hippocampus are morphologically part of dorsi-meson. The enormous development of the parietal part of the first embryonic vesicle which serves to bring much of the ventral surface dorsad, especially cephalad, causes a revolution correlated with the flexures which obscure the primitive simplicity, but in the rodents and marsupials, it is nevertheless sufficiently obvious.

2. The olfactory, as a sensory nerve, should have a trophic ganglion. This might lie upon the nerve itself, occupying a distinct fossa in the skull, like the Gasserian; it might be carried peripherad and become associated with the end organ, as in the auditory; or it might fuse with the brain itself to form an apparently organic unity. To us the latter seems the actual state of the case. If the tracts are really superficial, lying, for the most part, ectad to the neuroglia layer and, in spite of subdividing into several bundles, reach the same part of the brain; and if the so-called deep olfactory tract or olfactory bundle of the præcommissura springs, like other fascicles of that commissure, from cortex cells, there seems to be no reason for doubting (what is *a priori* so probable) that the adhesion of the pero to the pes is a comparatively subordinate character. In this case, while there may be more or less fusion and interblending of the two, there

is not a morphological but simply a mechanical connection between them.

3. The ganglion of the olfactory, if the latter be a true sensory nerve, should have chiefly trophic functions. There are several hints that the olfactory nerve is trophic. The fact that the fibres of the fifth or seventh nerve may upon occasion supply the place of the olfactory, if authenticated, might be significant in this connection.

4. The structure of the pero, with its large cells, might also be interpreted in this way. The fact that the fibres lose their sheaths in their passage through the pero, but acquire them at either exit seems favorable to this view.

5. The facts of comparative anatomy seem to us to admit of this interpretation. Of course a more careful and extensive comparison of data especially from embryology is necessary before the view thus tentatively suggested could be seriously advocated.

[It may be added that a somewhat extended study of the olfactory radices in lower vertebrates seems to confirm the above suggestions. In several papers in the *Journal of Comparative Neurology*, for 1891, the writer has shown the essential distinctness of pero and pes and the tracts related. It is especially evident in fishes where a distinct radix lateralis and mesalis relate the one to the pero the other to the pes, the former ending in the hippocampus, the latter entering the præcommisura.]

*Callosum and hippocampal commissure.* It is not necessary to recount the various opinions and discussions of the callosum in the marsupials. Until Osborn, most authors had agreed that the callosum is absent and functionally replaced by the anterior commissure. Professor Osborn has done much to place this whole subject in its proper light and we agree with him in respect to the essential homologies of the dorsal commissural system. In one group of fishes the callosum is present, as we have endeavored to prove in several recent papers, and is thoroughly distinct from the anterior commissure. The incomplete development of the cerebrum and especially the suppression of the free cortex causes the callosum to appear greatly displaced and it accordingly lies far cephalad in contiguity with the lamina terminalis in front and fornix body behind. We have too much evidence that structures pertaining to the brain when once acquired are not easily lost to be surprised if the callosum in some form exists in all verte-



brates. In the case of Didelphys the hippocampus and related structures are strongly not to say predominately developed. The motor cortex as such is thrown well cephalad and the fornicate gyrus is carried forward along the mesal surface, as may be seen from an inspection of the transverse sections of Plate A. Thus it happens that the caudal portion of the dorsal commissure system is much more highly developed than the cephalic or callosal portion. The latter consists of few fibres which spring from the region about the anterior prolongation of the splenial fissure, if this term may be applied to the fissure which bounds the cephalad continuation of the fornicate gyrus. The separation of the callosum and hippocampus commissure must be ascribed in great part to the folding of the hippocampus and its compression by the contact of the thalamus which leaves but one available path—that pursued by the fimbriae. It may be supposed that the cephalad point of fixation of the hippocampus is determined by the fornix bundles, which necessarily enter the corpus fornicis at a nearly constant point. That the fibres belonging to the fornix system are distinct from those of a commissural character was suggested by Stieda and seems quite probable from our observations.

The anterior commissure evidently is the chief coordinating commissure of the frontal portion of the cerebrum.

The easiest solution of the problem of the relations of the calloso-hippocampal commissure with the praecommissura would be to homologize the former with the dorsal, the latter with the ventral commissures of the cord. Yet the anterior commissure receives fibres from almost the entire surface of the cerebrum.

*The Praecommissura.* Of the three divisions of the anterior commissure which may be recognized, the so called olfactory portion has been sufficiently discussed in connection with the olfactory. The frontal portion is closely associated with it and these two are together less than the temporal branch. The fibres of the praecommissura hug the ventricles and are perforated by bundles from the peduncles.

Dorsad the commissure is bounded by the very large, nearly quadrangular, body of the fornix. Longitudinal sections of the brain at the median fissure show that the two hemispheres are connected by (1) a delicate membranous tela which springs from the cephalo-dorsal tuberosity of the thalamus and passes cephalad to unite with a conspicuous projection of the lamina terminalis cephalad of the hippocampal commissure and dorsad of the anterior commissure. This connection

is not direct along the very mesal line, but here the tela is distended to form a homologue of the dorsal sac of fishes which extend caudad to the epiphysis and is distinct from the aula except along the median line. Its walls give rise to abundant plexus. (2) The hippocampal commissure and fornix body form an oval mass dorsad of the anterior commissure and are attached to it. From the lateral aspects of the fornix body cephalo-ventrad the descending fornix tracts appear. In exactly median sections the fornix body is circumscribed on all sides except ventrad by the ventricle, while the tela springs from a special prominence, but laterad the tela adheres to the fornix body and can be traced to the free margin of the fascia dentata (gyrus uncinatus). (3) The anterior commissure itself is obscurely composed of three portions which are medianly rolled into a compact cylinder. Each has a sheath which can be seen under favorable circumstances. The dorsal and ventral parts are crescentic in section, while the median portion is oval. The dorsal crescent overlaps the ventral cephalad. (4) The lamina terminalis is medianly very thin but contains some gray matter. (5) The callosal fibres are too few to be very obvious in this view.

*Dorsal and Ventral regions of the Cerebrum.* We think there are good morphological and practical reasons for distinguishing the dorsal and ventral portions of the cerebrum as structures essentially distinct. The limits of the two regions are easily drawn in the opossum. Cephalad the olfactory crus with its cortex is very sharply distinguished from the pre-crucial portion dorsad of it. (Plate A, Fig. 2.) Here the cortex of the ventral portion is very largely covered by the olfactory fibres. Laterad, the two regions are limited, as we proceed caudad, by the rhinalis fissure, mesad the splenial fissure is an equally distinct boundary. Cephalad, these two fissures occupy nearly the same horizontal plane but caudad the former passes ventrad and the latter dorsad, a change which may be ascribed to the interposition of the thalamus. The ventral portion is distinct in cellular structure and presumably in function from the dorsal region. In the former two prominences have their origin, the pyriform lobe of either side caudad and the post-rhinal lobe cephalad. At the mesal union of the ventral and dorsal regions the hippocampus has its origin as a curious convolution at the splenial fissure. The hippocampus has been carefully described in rodents by C. Judson Herrick in Bulletin Denison Univ. Vol. VI. The relations are still more simple in marsupials and, because



of the absence of the callosum, they may serve as a type for comparison. Beginning at a region cephalad of the union of the two hemispheres (Plate A, Fig. 3.) we observe that the cortex at the splenial fissure becomes very narrow and dense and the cells acquire much the appearance of those of the hippocampus. The outer neuroglia layer is thickened and the peripheral fibre zone is collected in small tracts. These tracts, some of the fibres of which may represent the mesal olfactory tract, are thus described in my notes. "A tract which arises ventro-mesal near the crus of the olfactory (exact locality indeterminate) passes caudo-dorsad within the cortex. The several small bundles emerge into the neuroglia zone and before the formation of a deep splenial fissure have attained a position dorsad to it. Thence they pass caudad and are carried entad by the deepening of the fissure and are last seen in the region of the anterior commissure apparently terminating in cells of the uncinate gyrus."

Entad, a strong tract derived from the cells of this region passes meso-ventrad of the tract mentioned, is separated from the corpus striatum by a spur of the ventricle, and is filled with thickly scattered cells. An oblique band of cells passes from the ventricle ventrad toward the meson and seems a continuation of the irregular chain of cell-clusters characteristic of the pseudo-cortex of the ventral region. On the other side of the ventricle opposite the dorsal end of this cell-series is the cephalic branch of the anterior commissure. The limits of the gyrus fornicatus and uncinatus are more or less arbitrarily determined in mammalia. Ranney considers the posterior margin or splenium of the callosum the point where the former passes into the latter. In the present case, however, there being no such guide, we are forced to depend upon morphological modifications of the organs themselves. The gyrus fornicatus arises cephalad by the fold induced by the splenial fissure already described. It may be traced cephalad nearly to the olfactory. The uncinate gyrus is a second fold which appears as the two hemispheres fuse. (Plate A, Fig. 4.) The free dorsal margin is outwardly folded and at the same time "faulted" by being slid somewhat laterad as if by the agency of the thalamus wedged between the hemispheres. The fornicate and uncinate gyri are curved in opposite senses and related to each other somewhat as are tiles on a roof. In speaking of the uncinate gyrus as the free portion of the median cortex it must be understood in a limited sense, for the mesal margin passes into the plexus and tela and ultimately forms the connection

with the roof of the thalamus. The splenialis fissure grows deeper and curves ventrad, finally curving ventro-mesad (Plate A, Fig. 5.). Meanwhile, the medullary fibres of both the fornicate and uncinatus gyrus accumulate to produce the cephalad parts of the fornix. The relations remain nearly the same throughout the posterior parts of the cerebrum though the curvature of the hippocampus about the thalamus causes the transverse sections to fall in other planes. The longitudinal sections of Plate B show that the relations between the two gyri are maintained to the very subiculum.

The cellular structure of the hippocampus bears out the distinctions already made. The cells in both are densely clustered and form practically but a single series. The peripheral processes are from the apices of the elongate fusiform or spuriously pyramidal cells. The ental extremity is frequently almost equally prolonged. The nuclei are large and clear. The cells of the fornicate gyrus are nearly twice as large as those of the uncinatus and the latter also lie in a different plane, a fact due to the faulting or rotation of the gyrus as a whole. The structure of the hippocampus and its great complexity in other mammals is due chiefly to the flexure and caudad thrust of the callosum.

For a very complete historical account of the hippocampus and related structures see the works of Honegger<sup>1</sup> while the most recent work on the histology is that by Sala.<sup>2</sup>

After the painful attempt of Honegger to bring into harmony the infinitely diverse nomenclature of this subject we can but feel that a strict morphological terminology best meets the case. Embryology and comparative anatomy leave no doubt that we are dealing with two folds of the caudo-mesal cortex which are simply plicated and then curved upon each other. One margin of the structure is connected directly with the occipital cortex, the other with the tela and proplexus. The mesal convolution is the fascia dentata or gyrus uncinatus produced, the lateral convolution is the gyrus fornicateus. The alveus is the ental fibre zone of the gyrus fornicateus and the fimbria is the transition of the alveus into the fornix and hippocampal commissure.

<sup>1</sup> J. HONEGGER. Vergleichend-anatomische Untersuchung ueber den Fornix und die zu ihm in beziehung gebrachten Gebilde im Gehirn des Menschen und der Säugethiere. Genf. 1890.

<sup>2</sup> L. Sala. Zur feineren Anatomie des grossen Seepferdefusses. *Zeitschrift fuer wissenschaftliche Zoologie*. LII. I. 1891.



That portion of the cortex within the gyrus fornicatus is the stratum griseum circumvoluta of authors. The ectal tract of this convolution is the so-called lamina nuclearis. Meynert, with his usual morphological insight, recognized in the fascia dentata the free margin of the mesal portion of the mantle. These relations are especially well seen in Plate XVII. of Honegger's work. As Sala says, the sole difference between these gyri and other parts of the mantle consists in the fact that the cells are crowded into a single narrow layer. With the statements of Sala respecting the histological relations we are unable at present to agree. 1st. That author describes the cells of the fascia dentata (gyrus uncinatus) as splenial. We think that, when the cell body is preserved, it differs from those of the gyrus fornicatus chiefly in size, but it lies in a different plane. We are furthermore unable to discover how the distinction between the protoplasmic and nerve process is made out in cases where they are so similar. 2d. Sala states that the large cells of the gyrus fornicatus are functionally connected with the fibres of the alveus, while the apical processes subdivide interminably and terminate in the processes of neuroglia cells. The nervous processes may spring from either end of the cells and either pass directly entad to the alveus or ectad to the fibre layer immediately adjacent and then return to the alveus. If the evidence of our sections is to be trusted, the apical fibres pass directly into the ectal tract while the opposite extremity of the cell subdivides dichotomously, producing such a neuropilem as Sala himself figures, with which the alveus fibres may communicate.

It seems scarcely to be doubted from the course of the radix lateralis that its fibres reach the surface of the hippocampus and connect either directly or indirectly with the ectal layer of this region. The great mass of the alveus fibres are derived from the ental aspect of the fascia dentata. Thus, according to our view, the lamina nuclearis and superficial bundle of the fascia dentata are parts of the tract from the radix lateralis. Strong confirmation of this suggestion is found in the much simpler relations in fishes. (See forthcoming paper in *Journal of Comparative Neurology* for December.)

#### THE CEREBRAL CORTEX.

The cortex of the precrucial lobe may be regarded as typically motor, but even here there are many cells of the ectal series which divide at once into two or more strong processes and these in turn again divide dicotomously until a dense felting of fibres develops over

the ectal layer. Into this felting pass the apical fibres of the pyramids of the smaller size or ectal series. It is not easy to trace the ultimate course of these fibres, but in some cases, at least, they obviously divide into two and are lost in the neuropilem above referred to. Beneath the small pyramids at a variable distance is an ill-defined layer of larger pyramids whose apical processes seem also to pass into the neuropilem. Still entad of the giant pyramids are the usual multipolar cells adjacent to the white mater or fibre zone. More or less frequent in all of these layers, but especially entad, are large clear granular nuclei surrounded by unstained spaces which may represent the bodies of unstained cells of the aesthesodic type. In cases where the cell-body is stained it almost invariably has the apical process directed entad. The average length of the body of the small pyramids is about .03 min., while the giant pyramids are more than .04 min. exclusive of processes.

The cortex of the crus, i. e. of the lateral aspects of the cerebrum below the rhinalis fissure is the same as that of the ventral part of the cortex farther caudad.

Longitudinal perpendicular sections exhibit little difference between the cephalic and caudal portions of the dorsal cortex although the latter portion seems to possess proportionally more of the second type of cells.

In a section of the parietal region the neuroglia layer consists of an outer less densely stained layer and an ental layer which latter is suffused with stained matter evidently of an albuminous character. The inner layer may be called the ectal neuropilem zone because of its being filled with the finely dividing process of layers within. The anastomosis of these fibres, while very probable, has not been observed.

The cellular elements in this layer are inoblasts of connective fibres and Deiter's cells. Beneath the neuroglia is a band of cells forming the ectal portion of the cell-bearing cortex. The cells are small pyramids in part but a careful study shows that there are many cells of a somewhat different character, i. e. the peripheral process is not simple but branches dichotomously and then subdivides into a fine fibrillary felt. Immediately above and about this layer the felting of fibres is most dense and results frequently in a diffuse coloration rendering observation difficult. Beneath this layer there follow successive layers of small pyramids with some fusiform cells. The fibres from the apex in each case is continued to the ectal neuropilem zone there



dividing to mingle with the previously described fibres. The basilateral processes (there are no axial basal processes in the sense implied by Meynert) subdivide and form a diffuse mesh-work or felting which is nowhere concentrated to form a definite zone. Although it cannot be considered certain, it nevertheless seems probable from the appearance of the sections that these processes become associated indirectly with the cells next to be described.

The median and deeper parts of the cortex are everywhere, except in a few isolated motor nests, sprinkled with cells of a very different appearance. The cell-body scarcely stains with mercuric hematoxylin but the nucleus is brought out distinctly without being rendered opaque. The latter is large, often quite as large as the diameter of the smaller pyramidal cells. The contents of the nucleus are granular. The area about the nucleus may be vacuolate or the somewhat shrunken fusiform or irregular cell body may be sufficiently stained to be detected with care.

In a great many cases it is possible to trace the basilateral processes of the large pyramids to the immediate vicinity of these cells where they seem to form a loose reticulum.

The pyramids almost uniformly have near their bases one or more small dark nuclei such as we have called Deiter's bodies. The regions of the cortex near the white fibre zones are filled with multipolar cells with several basal and one peripheral process as the rule.

*Histology of the ventral part of cerebrum.* Fig. 1, Plate B illustrates the appearance of a horizontal section taken ventrad of the union of thalamus and hemisphere. Three distinct portions are presented; cephalad the large olfactory lobe with quadrangular outline and large ventricle. The pero is evidently separated from the pes by a ganglionic layer. The lobe obliquely applied to its crus so that the median surface extends much farther caudad than the lateral. The radix lateralis appears as a thick tract passing directly caudad to the pyriform lobe. The crura are long and connect with the ventro-median projections which we have called post-rhinal (or ventro-median) lobe. (The olfactory region is described in detail above.

The post-rhinal lobe is largely covered superficially by olfactory fibres. Entad to this are irregular clustres of cells and dense aggregates of Deiter corpuscles in opaque patches of neuroglia. The cells are of the type which we have termed rhino-morphic, i. e. are small irregular pyramids. Fig. 10, Plate A illustrates such cells upon the



confines of a clustre of Deiter cells. Within the cortex there are irregularly disposed sensory cells. It will be observed that the post-rhinal lobe lies in or near the anterior perforated area. Comparing the mammal brain with that of Sauropsida, it seems legitimate to conclude that these sharply localized clustres of corpuscles correspond to the proliferating areas of the axial lobe of the reptiles and birds. The presence of great numbers of vessels is essential for this purpose. The opaque color of the region in which the corpuscles are imbedded may be accounted for by the supposition that albuminous matter is collected about the proliferating centres. May it not be that those cells which are so uniformly associated with the large end of the pyramidal cells of the cortex are derived from this or some similar source? In this case, we have a novel modification of phagocytosis in the brain.

In the caudad portion of the post rhinal lobe, especially ventrad, the cell clustres and granular areas are especially numerous. The third portion of the section consists of the pyriform lobe, which at this level is similar in outline and size to the olfactory. The laterad, caudad and mesad are provided with a strong sub superficial zone of cells to be described more at length beyond but there is also a considerable admixture ventrad and mesad of the rhino-morphic cell type. In the central part of the pyriform lobe are numerous clustres of Deiter cells within clear spaces of the neuroglia, reminding one of those clustres or rosette-groups of cells found in similar regions of birds and reptiles.

*The cortex of the regions ventrad of the rhinalis fissure* has a habitus of its own. Immediately beneath the neuroglia layer the cortex is densely massed with only sparse pyramidal cells scattered entad without the stratification encountered in the dorsal cortex. The cells of the superior dense layer vary astonishingly in form, some being regular pyramids while the greater number are multipolar with numerous processes which pass into the neuroglia zone and there break up into a fine reticulum or felting of fibres which cannot in these sections be seen to anastomose or to enter the superficial tracts (radices of olfactory or otherwise). The deeper cells are chiefly pyramids and are frequently so isolated as to appear beautifully distinct. (Fig. 7, Plate C.) The apical process is generally peripheral and can be traced into the neuroglia zone where it can be seen in many cases to break up into numerous fine branches. The cell body is elongate pyramidal with numerous lateral and basilateral branches which subdivide and weave

themselves into the reticulum in which they lie. In only a few cases have actual anastomes been observed. The nuclei are large and elongate and there is a marked tendency for small corpuscles to associate themselves about the base between the spreading branches of these cells.

In some cases, especially toward the ental fibre layer the pyramids are reversed and the apex process passes centrad. Near the contact with the white matter the cells are rather multipolar than pyramidal and their chief process appears to pass into these fibre tracts. The white fibre layers at the surface in this region seem to be derived from the radix lateralis of the olfactory. Longitudinal sections seemed to indicate that the lateral radix divides or other fibres become associated with it, at least a band of obliquely-cut fibres may be seen ectad to those are passing directly caudad. The latter portion is thought to pass obliquely over the median surface to the hippocampus while the ectal portion seems to spread out in diminishing quantity upon this region. The vast quantity of fibres overspreading this region (i. e. lateral and ventral part of pyriform lobe) seems to preclude the possibility of all having been derived from the radix lateralis. The ventral regions of the pyriform exhibit pyramids mingled with large multipolar or fusiform cells with large clear circular nuclei. In some cases it seemed probable that the axial processes of the pyramids first described suddenly turn as they reach the neuroglia layer. In other cases and in the case of the superficial multipolar cells there is no doubt that the processes subdivide very minutely. This region of the neuroglia is so filled with non-medulated fibres as to stain more deeply than other regions. We seem here to have a neuropileum in the sense suggested by Koelliker.

In the infra-rhinal type of cortex strands of fibres may often be seen passing from the ectal nervous reticulum between the cells toward the central white matter. This is especially apparent at the caudal extremity of the pyriform lobe.

*Cortex of Occipital region.* In the lateral aspect of the occipital region dorsad of the rhinalis fissure we encounter a commingling of two distinct kinds of cells. The pyramidal cells are present over most of the cortex, being most numerous peripherally. They can be recognized by the deeply stained elongate nucleus and form of the cell. The second class consists of cells of a fusiform or pyriform (i. e. flask) shape. With the selective stains used, haematoxylin and Hg Cl<sub>2</sub>, the



nucleus alone stains in most instances and this not deeply. A reticulum within the clear nucleus is brought out, but, as a rule, no distinct nucleolus. Where the cell contour is visible it is as described above. Such cells are associated with the deeply stained pyramids in such a way as preclude the view that the difference could be due to varying treatment.

The distinction once relied on by us, i. e. the direction pursued by the apical process does not seem constant here. The deeper cells have the apical process directed entad while the ectal series may have the reverse position. The dorsal portion of the occipital region is occupied by these flask cells almost to the exclusion of all others. In longitudinal section at the posterior part of the cortex the following observations were made. There are here few pyramidal cells and a relatively large number of pale cells which contain large clear nucleoli and chromatin (?) mesh-work. The cell body is frequently so inconspicuous as to make the nuclei appear like free corpuscles. In many cases sufficient care will detect the cell outlines and in other spaces in the neuroglia testify of their presence. The outline of the cell is rarely as distinctly pyramidal as in the motor type through peripheral processes in some cases at least pass dorsad. See plate C, Fig. 6, which is a drawing of a portion of the occipital region (IV—7.) as seen with the one-fifth inch objective. *m.* is one of the pyramids and *s.* one of the supposed sensory cells. The almost constant presence of Deit'er's cells at the base of the pyramids will be noticed. This region may be contrasted with a typical motor area as drawn in Fig. 1 of the same plate or Fig. 2. A mixed area some distance beneath the ectal layer of cortex is drawn in Fig. 11, Plate A. In this case the sensory cells are almost unstained except the nucleus. (4—14.) In even the typical motor regions these pale cells are always present though in less numbers and mostly crowded to lower levels. Toward the posterior part of the hemispheres the cortex along the middle of the lateral aspect differs quite obviously from any other portions. The band is rather narrow and consists of small and slender cells which are in many cases pure fusiform elements, others are flask-cells, or rather inverted pyramids, but careful examination with one fifteenth inch objective (1500 diameters) shows that the process directed proximally does not form a single axis cylinder, as appears at first, but dissolves into several small fibres. Among these cells are a few with the usual pyramidal structure, but more slender than usual. Near the white

matter are large cells which change their direction to correspond with the direction of the tracts. This lateral area may have other functions than the dorsal or ventral area, but what the functions difference may be it is impossible to conjecture.

The motor regions of the cortex are illustrated by Figs. 1 and 2, of Plate C. Fig. 1 is a drawing made to a scale illustrating a strip of cortex extending from beneath the giant cells nearly to the upper cell layer. The region is in the fronto-dorsal cortex near the median fissure. The two drawings are part of the same strip of cortex, the right end of No. 1 being near the dorsal surface. The forms vary considerably, some of the cells being simply fusiform, others inverted pyramids while there are a few aesthesodic cells among them.

Fig. 2, is a camera drawing of the cortex from the deep pyramids to near the ectal layer. The apex processes extend beyond the cortex. The process of nutrition of the pyramids suggested elsewhere is well seen here. Several of the carrying corpuscles are often seen at the base of one pyramid. Fig. 4, Plate C, is a camera drawing of a few of the deep pyramids or giant cells under the one-fifteenth objective.

*The general conclusions* growing out of this investigation are briefly as follows: There is in the opossum a decided difference between the aesthesodic and kinesodic cell types. Regions known to be sensory contain a large number of the type with clear round nuclei. The delimitation of the areas is, however, very incomplete. This agrees well with the results of experiments. The two classes of cells are rarely unmixed in any area. In many cases at least the cortex cells give off processes which divide in the so-called neuroglia layer to form either a neuropile or reticulum. It would seem that a more or less connected reticulum of fibres directly supplied by the cells is the simplest anatomical device which can in any way be associated with unit states of consciousness.

The problem of nutrition of the specific nerve cells is, we believe, somewhat simplified by the suggestion that there are special proliferating centres in the brain base in which there are produced numerous corpuscles like Deiter's cells which then migrate to the cortex and convey nutriment to the cells. The small and frequently shrunken bodies at the bases of pyramidal cells are interpreted as such nutrient bodies from the sources indicated, one of which is the post-rhinal lobe near the substantia perforata anterior. With reference to the fact that

the cells regarded as kinesodic generally have their apical processes directed peripherad (the converse being the case with the æsthesodic,) it must be said that too much confidence should not be placed in this distinction. We now believe that the direction of the apical process is to be interpreted as a function of the direction from which the cell has migrated. We have shown in a series of papers that there is morphological and embryological evidence that the cortical cells are not formed in situ but have migrated from proliferating areas primarily found in the axial lobe. This suggestion has recently been greatly emphasized by the discovery that the axial lobe of fishes contains well marked areas of the two kinds of cells sustaining the proper relations to the tracts to enable us to identify them as motor and sensory respectively. It is believed that the motor areas of the cortex are supplied by cells which migrate from before backward and first lodge in the cortex, whence many subsequently migrate to deeper zones. Such migrating cells retain their connection with the peripheral source by means of the long apical processes. Sensory cells, having in many cases a different path of migration, naturally occupy different positions. In view of the recent results of Golge's method of staining, it would be premature to decide how far these processes are simply nutritive and how far actually nervous. It is significant, however, that the processes of nutrition apparently go on at the base of the cell as indicated by the nutritive nuclei there collected.

---

PLATE A.

A series of transverse sections through the cerebrum of the opossum.

*Fig.* 1. Section through the olfactory lobes.

*Fig.* 2. Section at the junction of the crus and post-rhinal lobe near the union of the rhinalic and splenial fissures.

*Fig.* 3. Section through the fore part of the cerebrum.

*Fig.* 4. Section through the anterior commissure and fornix body.

*Fig.* 5. Section at the caudal part of the anterior commissure, showing the encroachment of the radix lateralis mesad and the dorsal sac

*Fig.* 6. Section through the præthalamus and chiasm

*Fig.* 7. Section through the mesencephalon at the posterior commissure and hippocampus.

*Fig.* 8. Section through the occipital portion of the cortex and nates.

*Fig.* 9. Section through the cerebellum and pons.



*Fig. 10.* Portion of area of the post-rhinal lobe [region of Fig 3a,) embracing a portion of one of the granular masses as well as of the rhinomorphic cells.

*Fig. 11.* Portion of a section of the dorsal cortex near the meson. The figure embraces a region near the surface and shows two kinds of cells. The apex processes of the motor pyramids are very long, extending to near the upper level of the cortex, while the cells of the second type have the cell body almost unstained.

*Fig. 12.* Cortex of the mesal surface near its ventral limit. The mesal olfactory tracts are here breaking through the cortex. The position of the cells is disturbed and the apical processes dip out of the section. The surface is at the right.

#### PLATE B.

A series of eight horizontal sections through the entire brain beginning ventral and passing cephalad of the anterior commissure.

*Fig. 8.* A horizontal section through the superior commissure.

#### PLATE C.

*Fig. 1.* Portion of the cortex from the dorsal surface near the median fissure, extending as far entad as the giant pyramids. (Slide 28.) The cells are chiefly motor pyramids.

*Fig. 2.* Large pyramids of the parietal region, from a horizontal section. Camera drawing with one fifth inch objective.

*Fig. 3.* Ectad pyramid cells from præcrucial lobe near the median line. Camera drawing with one-inch objective.

*Fig. 4.* A few pyramid cells from the dorsal cortex drawn with one-fifteenth inch objective and camera. Observe the nutrient cells at the base in each case.

*Fig. 5.* Typical sensory cells from near the base of the cerebrum.

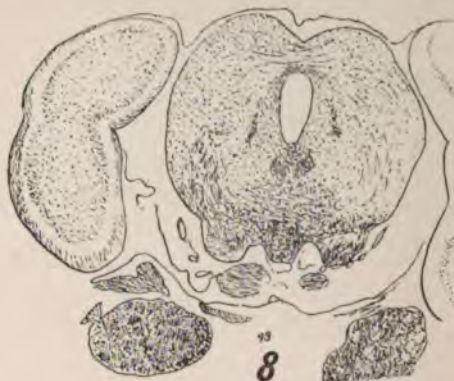
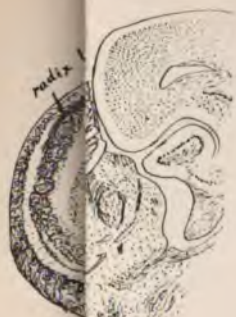
*Fig. 6.* Portion of the occipital cortex showing the two kinds of cells.

*Fig. 7.* Portions of the lateral cortex ventrad of the rhinalis fissure and beneath the olfactory fibre zone. The neuropileum above lies just entad of the radix laterals tract.

*Fig. 8.* Cells from the hippocampus at Fig. 5a, Plate A, showing the relations of the processes of the cells of the gyrus fornicatus to the ectal tract.

---

ERRATUM.—Page 86, line 11, for *splenial* read *spherical*.





*Fig. 10.* Portion of area of the post-rhinal lobe (region of Fig 3a.) embracing a portion of one of the granular masses as well as of the rhinomorph cells.

*Fig. 11.* Portion of a section of the dorsal cortex near the meson. The figure embraces a region near the surface and shows two kinds of cells. The apex processes of the motor pyramids are very long, extending to near the upper level of the cortex, while the cells of the second type have the cell body almost unstained.

*Fig. 12.* Cortex of the mesal surface near its ventral limit. The mesal olfactory tracts are here breaking through the cortex. The position of the cells is disturbed and the apical processes dip out of the section. The surface is at the right.

#### PLATE B.

A series of eight horizontal sections through the entire brain beginning ventral and passing cephalad of the anterior commissure.

*Fig. 8.* A horizontal section through the superior commissure.

#### PLATE C.

*Fig. 1.* Portion of the cortex from the dorsal surface near the median fissure, extending as far entad as the giant pyramids. (Slide 28.) The cells are chiefly motor pyramids.

*Fig. 2.* Large pyramids of the parietal region, from a horizontal section. Camera drawing with one fifth inch objective.

*Fig. 3.* Ectad pyramid cells from præcrucial lobe near the median line. Camera drawing with one-inch objective.

*Fig. 4.* A few pyramid cells from the dorsal cortex drawn with one-fifteenth inch objective and camera. Observe the nutrient cells at the base in each case.

*Fig. 5.* Typical sensory cells from near the base of the cerebrum.

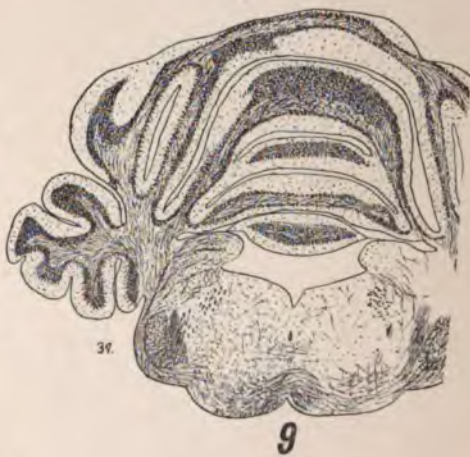
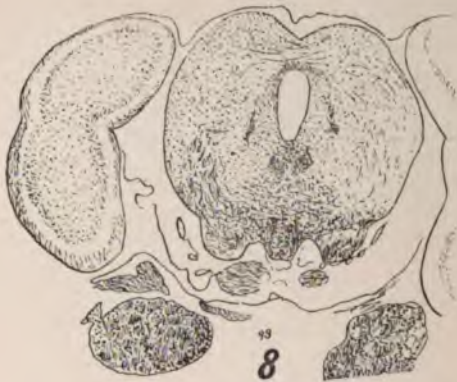
*Fig. 6.* Portion of the occipital cortex showing the two kinds of cells.

*Fig. 7.* Portions of the lateral cortex ventrad of the rhinalis fissure and beneath the olfactory fibre zone. The neuropileum above lies just entad of the radix laterals tract.

*Fig. 8.* Cells from the hippocampus at Fig. 5a, Plate A, showing the relations of the processes of the cells of the gyrus fornicatus to the ectal tract.

---

ERRATUM.—Page 86, line 11, for *splential* read *spherical*.



*Fig. 10.* Portion of area of the post-rhinal lobe [region of Fig 3a.] embracing a portion of one of the granular masses as well as of the rhinomorphic cells.

*Fig. 11.* Portion of a section of the dorsal cortex near the meson. The figure embraces a region near the surface and shows two kinds of cells. The apex processes of the motor pyramids are very long, extending to near the upper level of the cortex, while the cells of the second type have the cell body almost unstained.

*Fig. 12.* Cortex of the mesal surface near its ventral limit. The mesal olfactory tracts are here breaking through the cortex. The position of the cells is disturbed and the apical processes dip out of the section. The surface is at the right.

#### PLATE B.

A series of eight horizontal sections through the entire brain beginning ventral and passing cephalad of the anterior commissure.

*Fig. 8.* A horizontal section through the superior commissure.

#### PLATE C.

*Fig. 1.* Portion of the cortex from the dorsal surface near the median fissure, extending as far entad as the giant pyramids. (Slide 28.) The cells are chiefly motor pyramids.

*Fig. 2.* Large pyramids of the parietal region. from a horizontal section. Camera drawing with one fifth inch objective.

*Fig. 3.* Ectad pyramid cells from præcrucial lobe near the median line. Camera drawing with one-inch objective.

*Fig. 4.* A few pyramid cells from the dorsal cortex drawn with one-fifteenth inch objective and camera. Observe the nutrient cells at the base in each case.

*Fig. 5.* Typical sensory cells from near the base of the cerebrum.

*Fig. 6.* Portion of the occipital cortex showing the two kinds of cells.

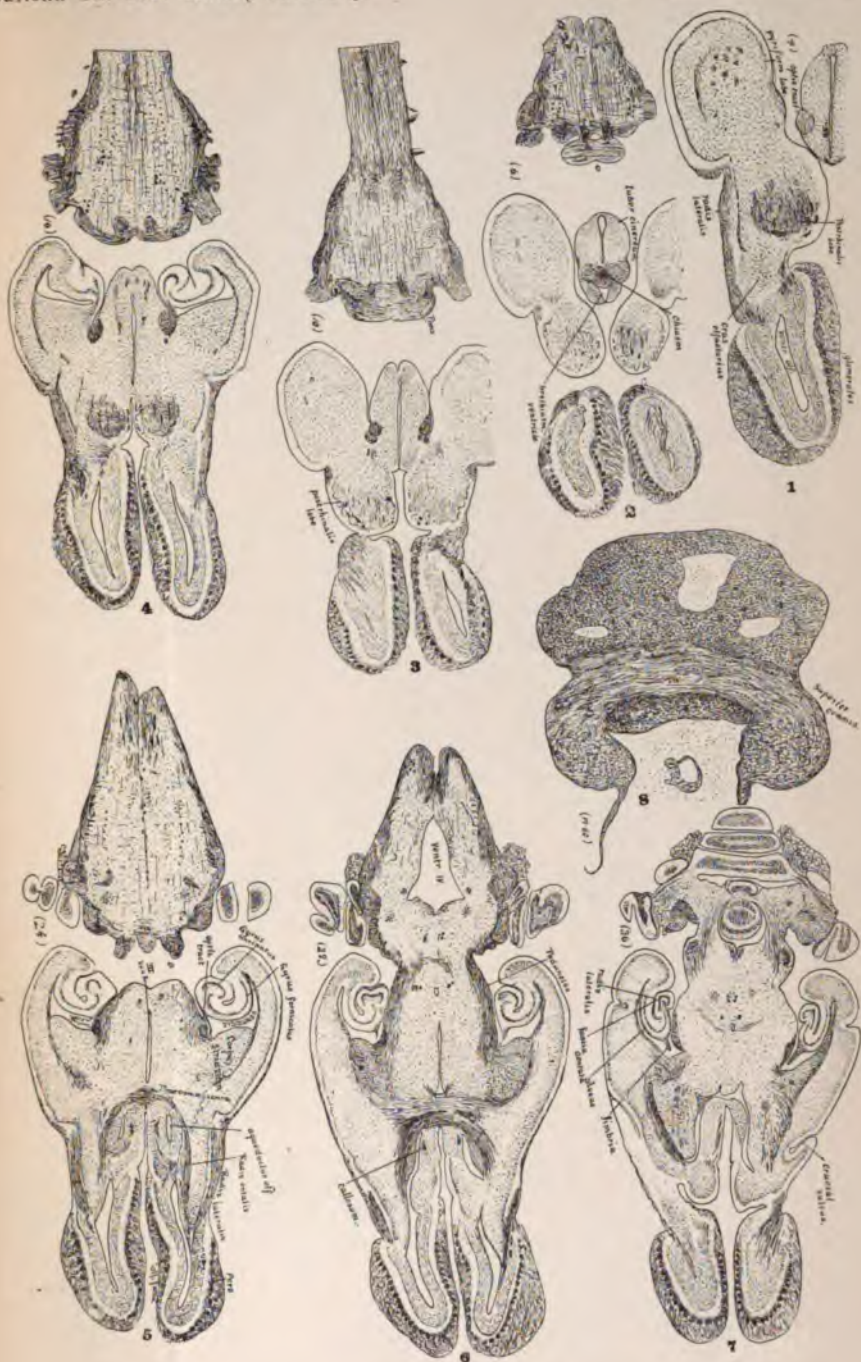
*Fig. 7.* Portions of the lateral cortex ventrad of the rhinalis fissure and beneath the olfactory fibre zone. The neuropileum above lies just entad of the radix laterals tract.

*Fig. 8.* Cells from the hippocampus at Fig. 5a, Plate A, showing the relations of the processes of the cells of the gyrus fornicatus to the ectal tract.

---

ERRATUM.—Page 86, line 11, for *splenial* read *spherical*.









6



5



7



THE NEW YORK  
PUBLIC LIBRARY  
ASTOR, LENOX AND  
TILDEN FOUNDATIONS.

PUBLISHED MONTHLY.

COMMENCED JANUARY 1888.

# The American Geologist.

ILLUSTRATED.

A Strictly Geological Journal.  
Two volumes of 100 pages each, per year.

*Subscription*

*\$3.50 per Year.*

Sample Copies, 20 cents.

## EDITORS AND PROPRIETORS.

Samuel Calvin, Iowa City, Iowa.

Edward W. Clappole, Akron, Ohio.

John Eyerman, Easton, Pa.

Persifor Fraascher, Philadelphia, Pa.

I. B. Tyrrell, Ottawa, Ont.

Robert T. Hill, Washington, D. C.

R. D. Salisbury, Madison, Wis.

Andrew C. Lawson, Berkeley, Cal.

Edward O. Ulrich, Newquar, Ky.

I. C. White, Morgantown, W. Va.

Newton H. Winchell, Minneapolis, Minn.

PUBLISHED AT MINNEAPOLIS, MINN.



JOHN HASTINGS, JOSEPH TRAPP, CHAR. S. LAWRENCE.

Pres. & Treas.

Vice Pres. &

Secretary.

Gen. Manager.

ENGRAVING FOR  
ALL ILLUSTRATIVE  
AND ADVERTISING  
PURPOSES

67-71 PARK PLACE,  
NEW YORK.



BARNES

PATENT

Foot-Power  
Machinery

FOR THE ACTUAL

## Business of the Workshop

Outfits complete,  
for Schools of In-  
dustrial Training.  
With them a prac-  
tical Journeyman's  
Trade, in wood or  
metal, can be ac-  
quired. Illustrated  
catalogue free.

Address,



W. F. & JOHN BARNES CO.,

479 RUBY STREET,

ROCKFORD, ILL.



1





